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Vol. 22 No. 3 SEPTEMBER, 1956

CONTENTS

Page

ARTICLES—

Some aspects of groundwater hydrology in Australia, by A. L. Tisdall .. 167
Resistance of higher plants to viruses, by R. J. Best .. 174
Cytological barriers in plant breeding, by R. D. Brock .. 180

TECHNICAL PAPERS—

Farming efficiency on some wheat and dairy farms in Victoria, by I. Molnar .. 189
Accessions of nitrogen (ammonia, nitrate and nitrite) in Western Australian wheat belt rains, by D. P. Drover and I. P. Barrett-Lennard .. 193
The influence of fungicide and fruit maturity on the development of ripe spot and target rot of apples, by G. C. Wade and J. R. Ward .. 198

TECHNICAL NOTES—

Wart disease of subterranean clover, by N. H. White, W. P. Cass-Smith and H. L. Harvey .. 204
A comparison of two fungicides for control of dollar spot, by J. H. E. Mackay and J. Brockwell .. 206
Garden peas successfully sod-seeded, by H. V. Jenkins, O. G. Carter and F. C. Crofts 207
An outbreak of phalaris staggers in sheep at Kojonup, Western Australia, by E. R. Watson .. 209
Comparison of microprojection and micronaire methods for determining mean fibre thickness of greasy wool, by W. R. Lang and V. M. Wright .. 211
Influence of moisture on efficiency of benzol in the control of blue mould of tobacco, by M. Mandryk and A. V. Hill .. 214

LETTER TO THE EDITOR .. 217

NEWS ITEMS .. 219

TALKS .. 225

BOOK REVIEWS .. 172, 179, 197, 203, 227, 231

BOOK LIST .. 232

INSTITUTE AFFAIRS—

Personal Notes .. 229
Branch Notes .. 230

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Manuscripts should be double spaced and should be submitted in duplicate, as part of the delay in referring is then avoided.

For more detailed information concerning the preparation and lay-out of scientific papers, authors are referred to the C.S.I.R.O. publication "Guide to Authors" and to an article entitled "The Preparation and Editing of Technical Papers" by N. S. Noble, published in the Australian Library Journal, April, 1954. The policy laid down in these publications is also largely followed by this Journal.

In addition to the contributions described above, the Journal is pleased to publish "Letters", "News Items", "Talks" and "Personal Notes" which have been received from, or which are of interest to, members of the Institute.

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ARTICLES

SOME ASPECTS OF GROUNDWATER HYDROLOGY IN AUSTRALIA

By A. L. TISDALL

Most people are familar with the term *hydrologic cycle*. Some of the water which falls on the land surface runs off through the natural drainage system to the sea. Here it is raised as water vapour, some of which will again fall on the land surface, thus completing the cycle. Some of the water will be retained in the surface soil, and will be available for growing plants; this water returns to the atmosphere in the vapour phase by evapotranspiration. Some of it will percolate to lower levels, where it may be held in an aquifer fairly near the surface and contribute to the rise of a local, or perched water table. Or it may reach a deep-seated aquifer, and may eventually find its way to the sea.

This water below the ground surface is an integral part of the hydrologic cycle, and although it has been receiving an increasing amount of attention in recent years, it will receive considerably more in the future, particularly in Australia.

Ultimately, the limiting factor in determining the population that can be supported in this driest of all continents is water. So far our main development has been in surface water resources. Every generation sees more giant projects developed, projects which were just not economically possible to an earlier generation, and no doubt more schemes for conservation of surface water will be possible to future generations. However, the limit of this type of conservation is in sight, and the next logical step is investigation of our ground water resources.

Of course, this has already been done in some parts of Australia. We have the development of artesian water for stock use; for instance the Great Artesian Basin of inland Austra'ia, which is the largest of its kind in the world, has been extensively explored and this has made stock-raising possible in vast areas which could not otherwise have been settled to any extent. As a rule though, this artesian water is too saline for irrigation. We have also schemes such as the Lockyer Valley in Queensland, where water for extensive irrigation is obtained from fairly shallow ground water. However, we are still a long way behind such States as California, where approximately 50% of the water used is pumped from underground.

Some Americans describe this type of problem as *hydrology* but to save confusion with climatologists, hydrographers, soil physicists, and ecologists, I prefer the more specific term *groundwater hydrology*.

The Irrigation Problem

One important aspect of this problem is found in irrigation areas. The advent of irrigation radically alters an existing hydrologic cycle. In high rainfall areas, the soils and land forms have developed under wet conditions, and over a period of geological time an equilibrium has been reached. In irrigation areas, we generally have a system which has reached equilibrium in a climate having somewhere be-

A. L. TISDALL, M.Agr.Sc., is Chief Irrigation Officer with the State Rivers and Water Supply Commission of Victoria. *This paper was delivered as the Presidential Address to the meeting of the Victorian Branch of the Institute on May 25, 1956.*

tween 10 and 20 inches of rainfall. We then add an extra 12 to 36 inches of water to this system every year, and consequently must expect an entirely different hydrologic equilibrium to be reached. New ground-water systems may be developed, or existing water tables may rise. As we cause these changes, we must be prepared to deal with their effects, when these effects upset our agricultural practices.

With perched water tables, we will be interested mainly in the first 20 or 30 feet below the surface. Even with widespread water tables, the depth will probably be only about 200 feet. In the Riverine Plain, which includes most of the irrigated areas of the Murray-Murrumbidgee river system and thus the majority of Australia's irrigated area, the sediments may be much deeper than 200 feet, and in fact in parts bores have been sunk to 600 feet without encountering bed-rock.

We have then a "no-man's-land," which is not primarily the concern of the pedologist or the geologist. Pedologists prefer to deal mainly with the soil to depths of 5 or 10 feet, while geologists tend to be interested in rocks rather than alluvial sediments. The material in between is the concern of the groundwater hydrologist who, as well as having some knowledge of pedology and geology, must also understand and be able to evaluate water movement through porous media.

H. N. England (1952), in N.S.W., has come to the conclusion that if the surface layers of the soil are saturated by irrigation, the rate of absorption of water will be governed, not by the permeability of these upper horizons, but by conditions underlying them, and so the deeper layers are important even when considering surface infiltration.

England and his colleagues have put their findings into practice, and now a considerable extent of the Murrumbidgee Irrigation Area is drained by pumping from a comparatively shallow aquifer.

Another and probably the most important factor in practice is that many of our irrigated lands have a naturally high salinity, particularly at depth. Irrigation will at first leach this salt downward, but as soon as a water table is built up to somewhere near the surface, soluble salts are concentrated near the surface and the soil deteriorates. This country has had its share of salt troubles, and over the last thirty years, much has been learned about the reclamation of salt-affected land, which is, of course, a special problem in hydrology.

Not all of our irrigated areas, however, have had these salinity problems to the same degree. The best explanation so far offered for the distribution of salt in the Riverine Plain, both in extent and in depth, is that of B. E. Butler (1950), who postulated that the present land surface was formed by the activity of a previous system of rivers and streams, which is not related to the present system. He considers that the plain was thus built up during late Pleistocene times from alluvial fans of prior streams, flowing from the mountains south and east of the plain. Traces of these streams can be found in many places, although their sediments overlap and the pattern is sometimes obscure. However, the overall effect is that the coarser sediments have been deposited close to the stream lines, the finer sediments remaining longer in suspension, and being deposited further out on the alluvial fan. Soluble salts would also tend to be carried further, and would thus be associated with the finer sediments.

If Butler's theory is sound, we would expect to find higher natural salinity in the soils as we move to the north-west away from the hills, and further out onto the plain, and indeed this is the case. As an example in our own State, soil salinity has not been a major problem near Shepparton and Tatura, while in the vicinity of Cohuna, Kerang and Swan Hill, some 20,000 acres or roughly one tenth of the

irrigated area is affected by salt to some extent.

A similar sequence is found in the irrigated areas in Central Gippsland, from Heyfield to Sale, although here the sequence of salinity appears to be more related to the present land form. The general fall is to the south-east, with the land draining to Lake Wellington. The country close to the lake is flat and very close to sea level, and is consequently difficult to drain. It is found that the soil salinity tends to increase as the land falls away to the south-east.

Butler's concept deals essentially with the redistribution of cyclic salt under low rainfall conditions, cyclic salt being the name given to the small particles of salt which are thrown into the air from sea spray, carried by the wind, and deposited on the land surface in the rain.

This explanation is possibly an oversimplification of the case, but does serve to show that soil degradation, due to salinity associated with rising water tables, must always be taken into account in irrigation systems, and also that by no means all our groundwaters are going to be suitable for agricultural use. Some of them will have to be regarded merely as a drainage problem, and if the water is to be moved, it will have to be disposed of where it will do no further harm. However, it is fairly obvious that we need to know a great deal more about the underground strata, so that we can determine the occurrence, quantity, quality and movement of the groundwater in irrigation districts, whether we are considering sources of water for beneficial use or merely means of effective drainage.

The Wider Application

So far we have discussed groundwater hydrology in relation to irrigation districts, which is a rather specific case. There are other examples which fit into the overall picture of man's interference with the hydrologic cycle. Sometimes this can have entirely unforeseen consequences.

In recent years, salting in the West Australian wheat belt has reached major proportions, with over 180,000 acres already out of production, and according to reports by Pennefather (1952) and Burvill (1956), with even larger areas threatened unless the present trend can be halted and indeed reversed. In West Australia, salting is apparently associated with restricted under-drainage due to an almost impermeable granite at shallow depths, coupled with sluggish surface drainage in a mature topography. Before settlement, the native vegetation helped to keep the water table, and hence the soluble salts, well below the surface, but clearing and farming operations upset what must have been a rather fine balance. Salting under natural rainfall conditions is not unknown in Victoria, as the Soil Conservation Authority has shown, but is not at all common in our wheat belt.

A situation such as this can only be remedied by understanding the hydrologic environment and studying how it will be affected by any proposed changes in land management. Investigations of such a complex hydrologic problem would involve forestry (the effect of clearing and also of re-afforestation); land policy (the type of land tenure and size of holding); pedology and geology (the nature of the soil and underlying bed-rock); engineering (the feasibility and design of surface drainage schemes), and agriculture (a variety of farm management problems).

Another example of the application of this work, a little closer to home, is the search for groundwater for town water supplies. The Mines Department in Victoria is at present engaged in such work, and as the water is generally artesian or sub-artesian, equipment capable of drilling to five thousand feet is planned.

There has been considerable development of groundwater for small irrigation projects in the Western District near the South Australian border, while bores and wells for domestic and stock purposes are found on farms all over the State. How-

ever, our knowledge of the aquifers, and water yields to be expected from them, is very inadequate as it is in most parts of Australia.

The legal aspect of groundwater should be mentioned. In Australia, legislation providing for the adequate control of surface waters in the public interest was introduced over fifty years ago, and has proved to be eminently sound. Indeed, compared with the United States, it has obviated a great deal of costly litigation. We have no such legislation dealing with groundwater but before long the matter will have to be seriously considered. Most of the American States where groundwater has been developed have found such legislation necessary.

Methods of Attack

A number of tools can be used to investigate groundwater. For local problems, such as channel seepage in irrigation areas, field work should commence as soon as the first symptoms of waterlogging appear. Shallow bores can be sunk by hand, or if greater depths are required, with a drilling machine. These are arranged on a grid pattern over the affected areas, to disclose the extent of the sand drift, and the section of channel responsible for seepage. Salt analyses on subsoils or on groundwater may be necessary as part of the investigation. Another useful tool is the *piezometer*, which is simply a length of piping, generally of about 3/8 in. bore, which is inserted vertically into the ground to various depths. It can be driven with a pneumatic hammer to a depth of 20 feet or so, but for greater depths, water under pressure is introduced down the pipe, which is thus gradually moved downwards with the help of the high velocity water jet. Piezometers are only open at the ends, and consequently the level to which the water rises in them is an indication of the water pressure at the bottom of the pipe. By using batteries of these pipes, it is possible to determine water pressure gradients, and hence the direction of water movement. The aim of these investigations is to discover potential danger points, and determine procedure to rectify the position before damage becomes extensive.

For more wide-spread problems, annual records of water levels and salinity, in deep and shallow wells and bores, need to be maintained over the whole district, and in order that the data may be reliable, it is necessary to conduct pilot groundwater surveys, to estimate the optimum number and spacing of wells necessary for this purpose.

Theoretically, it is possible to locate deep aquifers by the use of seismographic equipment. The principle is that shock waves from small controlled explosions near the ground surface are reflected from the water surface below, and recorded at ground level. From these records, it should be possible to determine the depth to groundwater, and some success with the technique has been reported from Western Australia. In south-eastern Australia, however, the heterogeneous nature of the deeper strata has so far rendered these seismic methods impracticable.

The water-jetting technique used to instal piezometers gives some information on the water movement between aquifers. However, we are reluctantly forced to the conclusion that there is so far no substitute for test boring and pumping, for determining groundwater yields and the physical and hydraulic properties of the aquifer.

Modern boring and drilling techniques are costly, and the number of bores that can be sunk is extremely limited. Although some information was collected by the U.S. Army during the last war, (see "Water Resources of Australia," 1942), and also by Gloe (1947), it must be admitted that in this State there is no definite procedure for the logging and recording of the bores which are installed for various purposes, and that our knowledge would be much more complete if this were so. A review of hydrologic data in Victoria has been prepared by K. D. Green (1953), who

points out that information on groundwater is by no means adequate.

The task of obtaining more data is therefore threefold; we should ensure firstly, that all boring carried out, for whatever purpose, adds to our knowledge of the geology and groundwater hydrology of the region, and secondly that investigational boring should be carefully placed so that it will return the most information for the limited boring which is at present possible. Finally, we should see that the information so obtained is published and properly disseminated to those who need it.

Planning

Other countries have attacked the problem realistically. The United States Geological Survey has for many years been collating information from all over the U.S.A. Admittedly these surveys cover a multitude of uses, but the determination of water resources plays a prominent part, as is shown by the publication "A Water Policy for the American People" (1950). More specifically, we have the "California Water Plan" as an example of planned development of water resources. After the dry years culminating in 1920, the State of California initiated studies in water resources, on the basis of which all the development of the Central Valley, California, and of the Colorado River in California and neighbouring States, has been carried out.

In 1947, investigations to extend and revise this plan were commenced, and it now appears (Simpson and Myer 1951) that California's water needs for the future can be met by development of both surface and groundwater in the north and north-west parts of the State. It should perhaps be pointed out here that most California valleys consist of fairly recent alluvium, with rather coarse-textured aquifers of considerable extent. Investigations in Victoria lead us to believe that the position is different here, but on information at present available, it is difficult to estimate our groundwater resources.

Other examples can be quoted. The French have undertaken a great deal of investigation in North Africa, and are much further forward with their knowledge of the groundwater hydrology of the region, and with the consequent development of their water resources. Israel owes its present state of development to the very thorough utilisation of groundwater resources.

Conclusion

It is true that pressure of population has been the motive force behind the development of these resources, and it is equally true that the same pressure must be expected in Australia in the not-too-distant future. Surface aspects of hydrology as represented by river gaugings and surface storage, have been the primary concern in this country; in fact, in Victoria, as early as 1905, our records had received international recognition for their accuracy and general completeness and even today are regarded as fairly complete. Australian climatology is also on a reasonably sound basis. On the other hand, the groundwater aspect of hydrology has been developed in few cases, and it is here that we find the biggest gaps in our knowledge. The first step would be the compilation and dissemination of the existing data, so that we can establish what precise information is necessary.

The final step will be the detailed and painstaking investigation of the groundwater aspects of hydrology.

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BOOK REVIEWS

LAND, WATER AND FOOD

By HERBERT ADDISON

(*Chapman and Hall, pp. 248, 1956, 18/- Stg.*)

Over the years one has formed a shrewd suspicion that engineers in general have a private conviction that they are superior to ordinary mortals. When let loose, they produce such magnificent structures, such vast expanses of concrete and steel, and turn out such enormous quantities of power or water, that their importance is almost superhuman. The result is that they seldom write books about their works which can be understood by the ordinary individual. This is a great pity, because after all, modern civilization does depend a great deal upon the success of the plans of the engineers.

As a result, this book is a great relief, because it provides a matter-of-fact story of most of the great enterprises which deal with the relationship of farming, land and water. Most of us are very ignorant about the basic problems of irrigation and irrigation planning in such countries as India and Africa. Particularly is this so in Australia, where we are rather apt to think that our relatively puny efforts at using water for agricultural purposes must be the last word in things. Perhaps everybody in Australia concerned with agriculture and irrigation ought to read this book so as to develop a more balanced view. We should then realise how superficial many of our efforts are, and the extent to which there may still be untapped possibilities for future irrigation in Australia.

The Author is not an agriculturist. He lays no stress on the relationship of soils and crop plants, which some of us have learned to be so important in successful irrigation. He does introduce us to the sociological problems which must confront every new scheme which is planned. On the other hand, I could not help feeling that the irrigation historian would not be quite happy about his suggestion that the Murray River Commission was the start of irrigation in south-eastern Australia. However, that is a trifling detail in a canvas which has world irrigation as its subject.

His final conclusions that further works will be more and more costly is probably correct, but some of us at least, have begun to realise that in the modern world the finance of capital construction can no longer be regarded in quite the same way as we looked at it in the 1930's. Further, it seems not unreasonable to think that a slight rise in the relative cost of foodstuffs to other expenditures, must be inevitable as the world slowly faces the need of bringing into agricultural production tracts of land which were previously beyond the economic margin of farming.

S. M. WADHAM.

THE NEMATODE PARASITES OF PLANTS CATALOGUED UNDER THEIR HOSTS

By T. GOODEY, O.B.E., D.Sc., F.R.S.

(*Revised, rearranged and brought up to date by J. Basil Goodey, Ph.D. and Mary T. Franklin, Ph.D.*).

(Commonwealth Bureau of Helminthology, Technical Communication (1) (140 pages). Obtainable from the C.A.B. Liaison Officer at 314 Albert Street, East Melbourne, C.2., Victoria Price 34/5).

Among the plant pathogens, the nematodes are of increasing significance. The recognition of the parasites, and control of the diseases produced by them, require a knowledge of the taxonomy and host-parasite relationships of these nematodes.

The late Dr. T. Goodey devoted a lifetime to their study, and it is due to him that the material used in the preparation of "The Nematode Parasites of Plants Catalogued under their Hosts" was collected, collated and preserved. The original publication was prepared by him and published by the Commonwealth Bureau of Agricultural Parasitology (Helminthology) in 1940. He maintained his records to his death and since then his son, Dr. J. Basil Goodey, has continued the practice. With Dr. Mary T. Franklin he has revised, rearranged and brought up to date this material.

The plant hosts are listed alphabetically with Latin and common names under the two chief headings, Phanerogamae and Cryptogamae, with the sub-headings Pteridophyta, Bryophyta and Thallophyta for the latter. There is an extensive bibliography.

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RESISTANCE OF HIGHER PLANTS TO VIRUSES

By R. J. BEST

Plants are unlike animals in that they do not produce anti-bodies. Nevertheless, they do resist infection by viruses. The fact of host specificity is proof of this. A survey of the literature reveals ample evidence for the existence in plants of virus-inactivating mechanisms, but a surprising paucity of information of what these mechanisms might be.

What do we mean by Resistance?

The most definite and satisfactory form of resistance is shown when a plant is immune, i.e., when it cannot be infected at all by a virus. However, since resistance to disease is quantitative and a relative quality, I assume that we should concern ourselves also with resistance which is not absolute. For example the ability of a plant to localise virus in the leaf or other part which received the virus initially may be accepted as a form of resistance, since the virus is unable to spread to other parts of the plant and infect it systemically. Because it is believed that this type of reaction happens when the virus multiplies so rapidly that it kills the cells it infects, it is called a "hypersensitive" reaction. Plants which are hypersensitive to a particular virus are clearly not immune or 100% resistant, because they have, in fact, been invaded, even if only to what might in practice be regarded as a negligible degree.

But once we accept this type of reaction as a form of resistance we need to be doubly careful not to fall into the error of assuming that any state of affairs which is associated with a lower concentration of virus in the host indicates the existence of a resistance mechanism, an inactivator or an inhibitor. For example, if the concentration of a virus is consistently higher in one variety of a host than in a second variety, then this may be due to *either* of two causes. One variety may be a better nutrient medium than the other, it may provide a better source of raw materials, such as amino acids, purines, pyrimidines, and the like, or the enzymes and sites necessary for multiplication. Alternatively, one may contain a more active or potent inactivating system than the other, i.e., it is more resistant to the virus; but until we have some evidence which will enable us to distinguish between the two possible explanations for the observed difference in virus content, we have no right to claim that an inactivating or inhibiting system is present in one, or that the one is more resistant than the other. Until this evidence is available, all we can properly claim is that one host is a more favourable medium for virus multiplication and survival than the other.

Another point to remember is that extent of damage is no criterion of resistance, one way or the other. Although it is probably more often true that the severity of symptoms is greatest in plants which offer greatest resistance to the virus, nevertheless, symptoms are probably more often the result of secondary reactions not directly related to virus concentration. (e.g., TSWV strain E on tomato and tobacco.)

I stress these points because the literature contains many papers in which the presence of inactivating systems or inhibitors is invoked when the evidence fits

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obvious alternative explanations equally well or better; and the severity of a disease is often erroneously considered to be a measure of susceptibility.

The Life Cycle of a Virus

Because viruses differ considerably from other pathogens in the intimacy of their relations with the host, it may be profitable to review what probably happens during the course of infection. It now seems certain that viruses have a "life-cycle" during one stage of which they actually become an integral part of the host cell. Problems of resistance are therefore complicated by the fact that at this stage any inactivation of the virus may be expected to act deleteriously on the host, and that inactivating and inhibiting mechanisms may be able to act effectively only at certain stages of the life cycle. Let us then, very briefly, review this life cycle, remembering that it has been reconstructed from studies of a few viruses only, and that any generalizations drawn are made for convenience, and are subject to alteration as more viruses are investigated.

The plant virus we keep in a test tube, outside the host, is in a resting state. It consists of nucleic acid and protein combined as nucleo-protein, and nothing else. Although the nucleic acid and protein components may be separated without denaturing them, both are needed for infectivity. The bare nucleoprotein has been called the initiator (Best 1956). This initiator carries the whole genetic memory of the virus by virtue of which it is able to organize the production of more initiator. Assuming that the initiator has been brought into contact with the cell, the first stage in the process of infection is for the initiator to adsorb onto a compatible surface. The nucleic acid component, either alone or accompanied by some protein, now enters the cell and there, by means at present unknown, enters the genetic mechanism and uses the enzymes of the normal cell to help produce more virus.

Just how it does this we do not know, but there is evidence for the following view. The viral ribonucleic acid (RNA) replicates itself at some active nucleoprotein-synthesising site and then synthesises the protein corresponding to the specific chemical configuration of the nucleic acid. It does this by assembling amino-acids into peptide chains about itself until ultimately an infectious nucleoprotein molecule is formed in which a nucleic acid double helix is wrapped in the protein "cocoon" it has spun around itself. (See, e.g., Watson and Crick 1953; Watson 1954; Franklin 1955.)

The various stages just described are shown diagrammatically in Figure 1.

Vulnerable Stages in the Life Cycle

It will be seen that the RNA, which would eventually become enveloped by virus-specific protein, will at some stages be naked and open to attack by the appropriate ribonuclease or other inactivants (Stages V and VI). Any substance or condition that can prolong the period that virus RNA is exposed would be helping to confer resistance on the plant.

If we view the whole process from the point of view of what factors might be concerned with resisting the entry and establishment of a virus we note that the first step of adsorbing onto the surface of a cell requires that the chemical configuration of the surface of the virus must be compatible with that on some portion of the cell wall. I think it is safe to assume that the initiator will adsorb effectively only onto a protein surface. If this is prevented by the presence of a non-protein layer or if the structure of any protein present is not compatible with that of the initiator, adsorption will not take place and the plant is immune.

Inhibitors could act at this stage (II) by blocking the compatible sites.

If the physical and chemical barriers to adsorption have been overcome the virus may still not be able to enter a cell. There may be further physical or chemi-

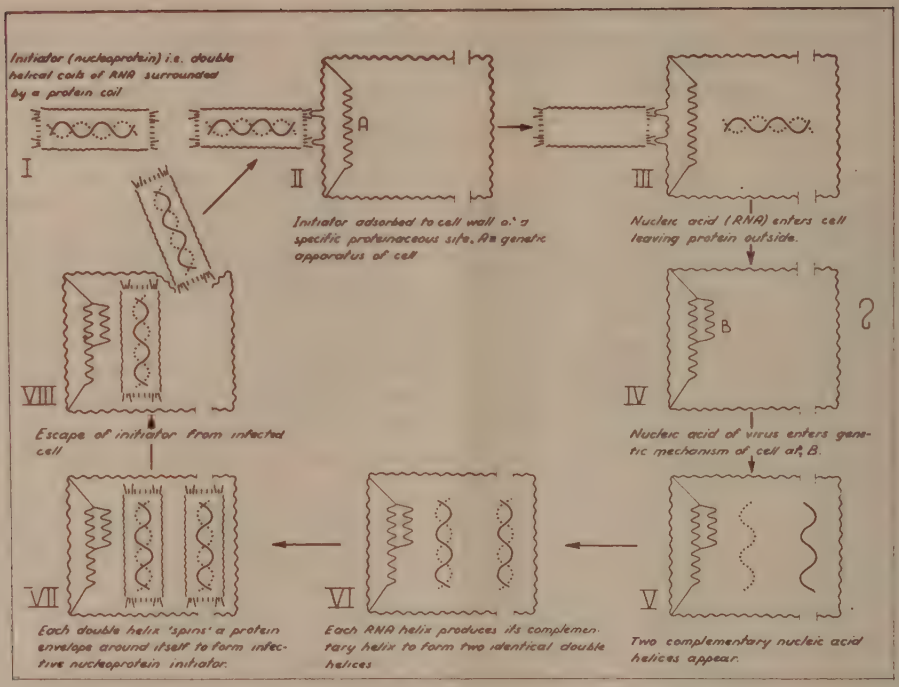
Initiator (nucleoprotein) i.e. double helical coils of RNA surrounded by a protein coil
I
II
A
Initiator adsorbed to cell wall at a specific proteinaceous site. As genetic apparatus of cell
III
Nucleic acid (RNA) enters cell leaving protein outside.
IV
B
?
Nucleic acid of virus enters genetic mechanism of cell at B.
V
Two complementary nucleic acid helices appear.
VI
Each RNA helix produces its complementary helix to form two identical double helices
VII
Each double helix 'spins' a protein envelope around itself to form infective nucleoprotein initiator.
VIII
Escape of initiator from infected cell

Figure 1.
Diagrammatic representation of the possible life cycle of a plant virus. The question mark at stage IV represents lack of information on mechanisms involved. (See text for explanation.)

cal barriers between the site of adsorption and the place where the nucleic acid enters the genetic mechanism, and the nucleic acid may be "inactivated."

Even after a successful entry has been made the virus may (i) be inactivated, (ii) be prevented from multiplying, or (iii) it may multiply but be inactivated by substances or processes resulting in the cell as a consequence of its own action. The balance between rate of replication and rate of inactivation would determine whether the virus would get a foothold and spread through the plant.

Inactivating Substances Found in Plants

What kind of inactivators have been found in plants?

Bawden and Kleczkowski (1945) have shown that leaves, stems, and roots of strawberry plants contain enough tannin to precipitate all the normal and viral protein they may contain and still have enough left to precipitate tobacco mosaic virus (TMV) so that it will not infect *Nicotiana glutinosa*.

Best (1937) has shown that tomato and tobacco plants contain an oxidisable substance of the catechol tannin type, and an enzyme, tyrosinase, which catalyses the oxidation of this substance by oxygen, and that the oxidised substance inactivates tomato spotted wilt (TSW) virus.

Both these reactions probably operate in virus infected plants as virus inactivants, but it must be remembered that in spite of them, strawberries still get virus diseases, and TSW virus still infects plants containing the inactivating system. It could well be that once the plant has become infected, the virus does not come directly into contact with such systems except when the cell collapses. Enzymes and substrates are then thrown together without being regulated and the results

could be lethal to the virus. Hypersensitivity may be one extreme form of such a process.

Salicylic acid and other derivatives of benzoic acid, urea and other organic substances, will inactivate viruses *in vitro* (Best 1940a, 1940b; Bawden and Pirie 1940). Substances analogous to these may be present in plants and have a similar effect, but data are quite inadequate to allow more than speculation.

Likewise, the role of 6-methoxy-7 hydroxy 1, 2 benzopyrone, shown to accumulate in virus infected plants, still awaits elucidation (Best 1936, 1944, 1948; Andraea 1948) but it seems to be associated with a resistance process.

Inhibitors

Since Allard (1914, 1918) showed that the juice of the plant *Phytolacca decandra* (pokeweed) inhibits infection by TMV, a considerable number of plants have been found to contain something that inhibits infection by viruses (e.g., Grant 1934; Kuntz and Walker 1947; Crowley 1955) but only in a few cases have the substances responsible been isolated and investigated. Kassanis and Kleczkowski (1948) have isolated a glycoprotein with 14 to 15 per cent. Nitrogen and 8 to 12 per cent. carbohydrate as the active principle.

It is doubtful whether these inhibitors confer resistance. In spite of the presence of inhibitors in higher plants they become infected by the viruses susceptible to the inhibitors they themselves contain. Might it not, perhaps, be the other way about, namely, that the presence of inhibitors converts what might have been a hypersensitive plant into a tolerant carrier?

Some of the growth products of bacteria and fungi act as inhibitors of infection. Extracts of the fungus *Trichothecium roseum* were shown by Gupta and Price (1950) to inhibit a number of viruses; and Bawden and Freeman (1952) found two active components (1) trichothecin, $C_{19}H_{24}O_5$, an isocrotonyl ester of trichothecolone, and (2) a polysaccharide containing 1.1 to 1.4 per cent. nitrogen and 60 to 70 per cent. of reducing sugars.

The enzymes trypsin and pancreatic ribonuclease also act as inhibitors.

It is not easy to decide whether inhibitors act on the virus itself or on the host or both. In general, the evidence favours the view that the chief mode of action is on the host plant. For example, the same virus applied to different hosts may be inhibited on one and not on another. Furthermore, the same amount of inhibitor has a relatively greater inhibiting effect on concentrated than on dilute virus solutions, i.e., as the ratio of inhibitor to virus increases the inhibitory effect decreases. (Kassanis and Kleczkowski 1948; Crowley 1955.) In all the above cases it is *infection* that is inhibited. Once a virus has begun to multiply its progress is unimpeded by these inhibitors, i.e., if put on a plant or injected into it after multiplication has started there is no effect.

There are other inhibitors (e.g., thiouracil, 8-aza-guanine, etc.) which seem to slow down the rate of virus multiplication in the plant. Guanine is a normal constituent of nucleic acids and is present in all plant viruses investigated. Matthews (1953a and b) has shown that the introduction of the analogue 8-aza-guanine (which does not occur naturally) into a plant slows down the rate of virus multiplication and that 8-aza-guanine is actually incorporated into the nucleic acid of the virus. His explanation is that the virus cannot distinguish between the pure and the substituted guanine and incorporates some of the latter but the particles containing the substituted guanine cannot now multiply.

Thiouracil seems to alter the metabolism of the host. (Bawden and Kassanis 1954.)

In themselves most of the substances tested may have little importance in nature but other analogues occurring naturally may act in a similar way. Observations like the inhibitory action of

malachite green (Takahashi 1948; Norris 1954) seem not to have been followed up with a view to determining mechanisms, but follow-up work of this kind would contribute to the discovery of basic principles.

Conditions which Affect Infection and Multiplication

Perhaps we can get an insight into the mechanisms of host resistance to virus infection if we examine the factors which influence susceptibility, such as the physiological stage of development of the host, the temperature, light and host nutrition.

Conditions of light and temperature before and after inoculation have been shown to effect virus multiplication.

Differences in the number of local lesions produced when plants were treated differently before inoculation suggest that environment and treatment influence the number of susceptible sites (or cells). Differences in the number of local lesions produced when plants are treated differently *after* inoculation lead to the conclusion that not all adsorbed virus multiplied to the extent where visible lesions developed, and that consequently an inactivating mechanism is at work which is more effective at one temperature than at another.

Similar conclusions may be drawn from some observations on the effect of light (Best 1936; Bawden and Roberts 1947).

It also seems that conditions which favour protein hydrolysis also favour infection but that actual multiplication of viruses is favoured by conditions which favour protein *synthesis.*

Host Nutrition modifies the effect of viruses. In general the better nourished a plant is the more susceptible will it be to virus activity.

Competition for essential "nutrients" between host and virus does not seem to be at all important in resistance.

Physiological stage of development. The literature is full of examples to show that the susceptibility of hosts to a particular virus varies greatly with the physiological stage of development of the host. One example will serve to illustrate this: strain E of tomato spotted wilt virus will invade *Nicotiana glutinosa* plants systemically only if they are below a certain critical age. If inoculated onto plants that have passed this age it will remain localised in the inoculated leaves.

The Genetical Approach

Geneticists have shown that resistance and tolerance towards some viruses are associated with certain genes. An excellent review of this field has appeared recently (Holmes 1954). It should be pointed out, however, that the recent demonstration that strains of a plant virus can exchange genetic units and so produce many new strains may cause complications. (Best and Gallus 1955; Best 1955.)

Summing Up

That plants contain systems which inactivate viruses seems certain, and also that most are gene-controlled. But the underlying chemical mechanisms are largely unknown. The most hopeful approach to discovering the nature of host resistance seems to me to lie in a study of the causes of *host specificity.* I have already mentioned the specific configuration of the proteins at the site of adsorption. Nucleic acid specificity of viruses may be another factor which influences this host specificity. Investigation of the chemical bases of these relationships is fundamental to the whole problem.

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BOOK REVIEWS

WATER — THE YEAR BOOK OF AGRICULTURE — 1955

By ALFRED STEFFERUD

(*For sale by the Superintendent of Documents, Washington* 25 *D.C.*, 750 *pages. Price* $2.00).

"I have little need to remind you that water has become one of our major national concerns," says E. T. Benson, Secretary for Agriculture in his foreword to "The Year Book of Agriculture," for 1955. The Editor, Alfred Stefferud, starts his preface by saying "There is a lot to be known about water."

A study of the book will make the reader aware of the truth of both these statements. He will find that it is full of valuable information and that, unlike most of the previous yearbooks, the subject matter is largely applicable to Australia.

The contents are divided into thirteen chapters and each chapter contains a number of articles which are written by specialists. Ninety-seven such articles, all dealing with some aspect of water, are included. There is a total number of one-hundred-and-forty-six authors, but careful editing ensures smooth reading.

The opening chapter entitled "Our need for Water", gives an account of the tremendous demands on water made by all forms of life, while the chapter "Where we get our Water", deals with the phases of the hydrologic cycle. Under the heading "Water and our Soil", erosion is discussed in relation to geomorphology, and "Caring for our Watersheds" explains the effects of soil erosion in catchments. Various land-use practices and their effects on catchments are described. One type of land-use, forestry, is discussed in a separate chapter entitled, "Water and our Forests."

The many aspects of irrigation are dealt with under "Water and Irrigation", and this subject is further considered, in the following two chapters, in relation to crops and pastures.

Other chapters deal with drainage, discussing the various methods and their effects. Smaller chapters give interesting information on "Water and Wildlife" and "Water Supplies for Farms and Cities," as well as the use of water for gardens, turfs and orchards.

The book ends appropriately with a chapter entitled, "A Look to the Future".

"Water" gives an up-to-date picture of hydrologic thinking in the United States. As it quotes sources of information it provides for those who seek more detailed information, and further reading is often referred to at the end of the chapter.

The volume is highly instructive to agricultural scientists, foresters and engineers, and can also be read to advantage by laymen. Illustrations include good photographs and fine pen drawings.

S. PELS.

CYTOLOGICAL BARRIERS IN PLANT BREEDING

By R. D. BROCK

Introduction

The value of plant breeding to agriculture in Australia requires little elaboration. The pioneering work of Farrer has been followed by half a century of breeding and selection for improved yield, quality and disease resistance. During this period the disciplines of genetics and cytology have been established. These have led to a better understanding of the principles underlying plant breeding but, have they contributed to greater efficiency in plant breeding? This can be answered in part by a review of some recent cytological advances and the bearing these have on the problems encountered by the plant breeder.

The greater use, or attempted use, of interspecific and intergeneric crosses results from the ever-broadening search for desirable genes for transfer to commercial crops. Many such genes, including those for disease resistance, frequently occur only in related species or genera and unless these can be incorporated into the commercial crop the effectiveness of the plant breeder is severely restricted.

In wide crosses such as these, barriers to development occur at many stages (Fig. 1) preventing fertilization, seed development, germination or growth. Even if no difficulty is experienced in producing the hybrid, abnormalities at meiosis and in the gametophytic stage often reduce fertility to such an extent that the production of viable gametes and seed is negligible. Such difficulties occur less frequently in crosses between more closely related parents.

Cytological studies define the nature of the incompatibility or sterility, permit an assessment of the importance of these sterility barriers to the plant breeding programme, and in many cases suggest ways in which they can be overcome.

Fertilization and Seed Development

We should perhaps consider briefly the processes of normal fertilization and seed development. The pollen germinates on the stigma and grows down the style; on penetrating the embryo sac the pollen tube bursts, releasing the two haploid pollen tube nuclei. One of these nuclei fuses with the haploid nucleus of the egg to form the diploid zygote which develops to form the embryo. The other pollen tube nucleus fuses with the two polar nuclei of the embryo sac to form the primary endosperm nucleus.

The embryo develops slowly at first and later more rapidly. The primary endosperm nucleus divides almost immediately and develops rapidly into the endosperm. The primary function of the endosperm is to provide a medium in which the young embryo develops. During this early phase the young embryo is totally dependent upon the endosperm. Its nutrient supply is passed through the endosperm and as we shall see later the developing endosperm plays a role in auxin production. As the embryo becomes larger it becomes independent of the endosperm which in some plants degenerates and is absorbed (non endospermic seeds, e.g. beans), in others it assumes the secondary function of a food storage organ for the seed (endospermic seeds, e.g. wheat).

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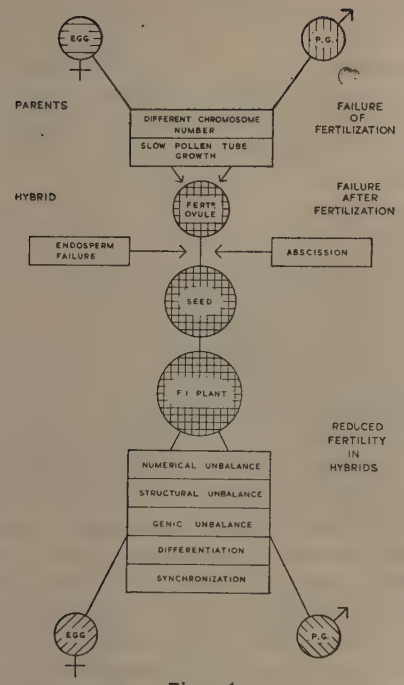

Figure1.
Sites of cytological sterility barriers.

Failure of hybridization can be caused by abnormalities occurring either before or after fertilization with the consequence that no viable seed is formed.

Failure of Fertilization

Abnormal pollen germination and growth is a frequent cause of failure of fertilization and this can sometimes be overcome.

Pollen germination can be stimulated by appropriate concentrations of hormones and vitamins (Smith 1942, Addicott 1943) and Evans and Denward (1955) used the hormone β-naphthoxy-acetic acid in this way as an aid to interspecific hybridization in *Trifolium*.

Sometimes pollen tubes grow too slowly or do not grow to sufficient length to effect fertilization. An inbred line of maize with exceptionally long styles will not set seed when either self or cross pollinated. This type of incompatibility was overcome by the simple device of shortening the style before pollination (Singleton 1946). Some interspecific crosses in *Nicotiana* between long and short styled plants failed where the species with long styles was used as the female parent but the reciprocal cross was successful (Kostoff 1941). A similar difficulty was encountered when attempts were made to hybridize pears and apples. A study of the growth of apple pollen in pear styles revealed that the apple pollen grew so slowly that it had not reached the ovule by the time the pear flowers were dropped from the tree. However a variety of substances, including hormones and vitamins, will stimulate pollen tubes to grow faster (Smith 1942, Addicott 1943). A solution of β-naphthoxy-acetic acid when applied to the style of the pear plant accelerated the growth of the apple pollen sufficiently to allow fertilization to occur (Brock 1954a).

Differences in chromosome number between the parent plants frequently constitute a barrier to crossing. The varieties of subterranean clover with 16 chromosomes will not hybridize with those of the sub species *Telavivensis* which have 12 chromosomes (Yates and Brittan 1952). Similarly the two diploid species of *Lamium, purpureum* and *amplexicaule* (2n = 18) will not hybridize with one another or with the allotetraploids *hybridum* or *intermedium* (2n = 36). The reasons for failure of hybridization have not been fully investigated, but when the chromosome number of the diploids is doubled by colchicine treatment, the resultant autotetraploids will then hybridize readily with one another and with the allotetraploid species (Bernström 1953).

In plants where the technique of hybridization is difficult, through smallness of floral parts or early dehiscence, it is often difficult to know whether a cross fails because of a true incompatibility or because of technique difficulties. Recent work by Evans and Denward (1955) is interesting in this respect. They have

compared the graft compatibility of a number of *Trifolium* species with their sexual compatibility (crossability) and found a positive correlation. This diagnostic technique may be of great use to plant breeders if this relationship is found to be widespread. Contrary to the claims of Lysenko and his followers they found no evidence of graft hybridization or influence of the stock on the sexual compatibility of the scion.

Failure after Fertilization

Failure after fertilization can be due to failure of the endosperm to provide a satisfactory medium for the developing embryo, to the developing seed being lost by abscission, or to zygotic failure.

Endosperm Failure

Failure of the endosperm and the subsequent abortion of an otherwise normal embryo frequently occurs after wide crosses (see Brink and Cooper 1947 for review). Little information is available as to the genetic control of such failures and the position is complicated by the different chromosome number of the endosperm in different species. In over 85% of the angiosperms the endosperm is triploid; in the *Oenotheraceae* it is diploid; in some members of the *Liliaceae* it is pentaploid; and in a few genera it is 9-ploid or 15-ploid (Maheshwari 1951).

In *Oenothera* the diploid endosperm is subject to the same genetic control as the embryo. Zygotic lethal factors act in either the embryo, or endosperm or on both, resulting in embryoless seeds, shrivelled seeds or no seed development (Hiorth 1926). However, in triploid endosperms the situation is more complicated. In maize there are genetically determined shrunken or shrivelled endosperms. The "twin spot" maize endosperms led McClintock (1941) to the conclusion that a chromosome breakage cycle was operating. She postulated chromosome breakage followed by reunion of the broken ends of the chromatids. Anaphase separation would produce a bridge. Non-median breakage of this bridge would result in duplication of portion of the chromosome in one nucleus and a deficiency in the other. These genetically different nuclei resulting in different endosperm characters and in this way producing "twin spots".

The association of cytological abnormalities with endosperm failure was indicated by much of the earlier work (see Brink and Cooper 1947) but it was not until new techniques for endosperm study were developed that these cytological abnormalities could be fully investigated. In interspecific *Lilium* hybrids and intervarietal *Hyacinthus orientalis* hybrids (Brock 1953, 1955) the cytological abnormalities were subjected to detailed study. In the *Lilium* hybrids endosperm failure is severe and is associated with spontaneous chromosome breakage. This breakage accumulates and intensifies with successive mitoses, culminating in mass chromosome breakage, cessation of mitotic activity and premature degeneration of the endosperm. No cytological abnormalities occur in the embryo which fails simply as a consequence of the endosperm failure.

The severity of the abnormalities in the hybrid *Lilium* endosperms may be associated with high chromosome number, for these endosperms are pentaploid ($5x = 60$). However a similar sequence of events occurs in some of the triploid endosperms found in crosses between hyacinth varieties. Hyacinths are unusual in that the commercial varieties range in chromosome number from diploid ($2n = 16$) to almost tetraploid ($2n = 31$) with all of the intermediate numbers viable. This situation permits a study of the effect of increasing the chromosome number on the severity of endosperm failure. It was found that as the chromosome number is increased so does the endosperm failure increase. However some failure occurred in endosperms where there are no extra chromosomes (diploid x diploid crosses). This indicates that

the errors are basically under genetic control but they can be influenced by chromosome number.

Is this sequence of events leading to endosperm failure and embryo abortion peculiar to hyacinths and lilies or does it occur more generally?

Many of the reports of endosperm failure in other species include accounts of chromosome breakage and mitotic abnormalities. These frequently occur after crossing plants of different chromosome number, both in crosses where there are wide genetic differences (hybrids between species) and in those in which there is little genetic difference between the parents (diploid x autotetraploid).

Chromosome breakage is of wide importance in failure of interspecific hybridization. Kihara and Nishiyama (1932) report giant nuclei, irregular mitosis, nuclei fusion and degeneration in endosperm of the hybrid *Avena strigosa* (n = 7) x *A. fatua* (n = 21). Boyes and Thompson (1937) report varying degrees of abnormalities in the endosperm of the hybrid *Triticum durum* (n = 14) x *T. vulgare* (n = 21), *T. dicoccum* (n = 14) x *T. vulgare* and *T. monococcum* (n = 7) x *T. spelta* (n = 21). Cooper and Brink (1944) report chromosome bridges, dumbbell shaped nuclei and highly polyploid nuclei in the endosperm of the hybrid *Hordeum jubatum* (n = 14) x *Secale cereale* (n = 7). Endosperm failure also occurs in the cross between rye and barley (Thompson and Johnston 1945) and in the cross *Hordeum vulgare* (n = 7) x *Hordeum bulbosum* (n = 14), (Brock unpublished).

Similar errors also occur in diploid x autotetraploid crosses in *Lycopersicon* species (Brink and Cooper 1947), and Rappaport *et al.* (1950a, b) report seed failure in interspecific and in diploid x autotetraploid crosses of *Datura*. These seed failures are characterised by failure of the embryo and endosperm and the development of ovular tumors.

Thus it seems that the sequence of events, beginning with spontaneous chromosome breakage in the endosperm and culminating in endosperm failure and embryo abortion, is not confined to lily and hyacinth crosses but is a common cause of seed failure after crossing.

In all of these cases as with the Lilium and the hyacinth crosses no abnormalities occurred in the embryo. This provides the key to the solution of this problem from a practical point of view, for if the normal embryo can be removed from the unfavourable environment and cultured on artificial media it will grow into a vigorous F1 plant. Endosperm failure can sometimes be alleviated in another way for in cases where failure follows crossing between plants of different chromosome number (e.g. diploid x tetraploid) the severity of the abnormalities frequently differs in reciprocal crosses. Hence the cross may fail in one direction but succeed in the reciprocal. However as we shall see later, neither of these is a complete solution to the problem for when this F1 plant reaches its next period of stress—meiosis—its unbalanced condition will become apparent.

Abscission

Endosperm failure is not the only process by which a developing embryo can be lost before it forms a viable seed. We have seen that in pear-apple hybrids the application of hormone accelerates pollen tube growth and allows fertilization to take place. However the hormone has a second role, for in these experiments the cross failed unless the hormone was capable of inducing parthenocarpic fruit development. The apple pollen tubes, although accelerated, still took five days longer than pear pollen to reach and fertilize the pear ovule, hence the hormone must delay the formation of the abscission layer (which normally sloughs off unfertilized flowers) so that the young hybrid is not lost. The hormone used here, β-naphthoxy acetic acid, while inducing parthenocarpy in pears does not do so in

apples. Hence it is not surprising that the reciprocal (apple-pear) cross fails when this technique is used. Another hormone, α-(2 naphthoxy) propionic acid, does induce parthenocarpic fruit set on some varieties of apples and, although this has not been tried, its use in conjunction with pear pollen would probably permit apple x pear hybridization. The success of this technique thus depends on—(1) a general reaction (acceleration of pollen tube growth) which can be induced by a number of substances on a wide range of pollen; and (2) a specific reaction (induction of parthenocarpic fruit set) where the correct type and concentration of hormone often varies from species to species. Extension of this technique to other crosses must thus be based upon selection of the hormone and the concentration which will induce parthenocarpic fruit development.

This technique has been used as an aid to interspecific crosses in lilies (Emsweller and Stuart 1948) and tomatoes (Rick unpublished). Numerous plant breeders now recognise and use it as an aid to crossing.

Zygotic Failure

Crossing plants of different chromosome number will result in progeny with a range of chromosome numbers. Most progeny with numbers removed from multiples of the haploid set are unbalanced and inviable. Even in hyacinth, although a much wider range of total number is permissible, there are nevertheless clearly defined balances between the different types of chromosome (five types can be distinguished morphologically). In most cases it is not known at what stage the unbalanced types fail. It is generally assumed that unbalanced pollen grains and eggs are incapable of affecting fertilization but recently doubts have been cast upon this.

In *Drosophila* unbalanced gametes are known to be capable of effecting fertilization (Demerec and Kaufmann 1940). These normally cause failure of the zygote at an early stage. Recently Brown and Cave (1954) have shown that unbalanced pollen grains of *Lilium* (resulting from large doses of X-rays) are capable of effecting fertilization and again they cause failure of the zygote at an early stage.

In hyacinth we know that at least one deficiency (one arm of one chromosome) can be transmitted through the pollen grain and effect fertilization (Brock 1955). This deficiency does not prevent seed development and germination and so far has shown little sign of impairing vegetative growth.

Failure of Vegative Growth of the F1

After wide crosses it is not uncommon to find difficulties in seed germination and abnormal seedling growth. Some of the difficulties in germination undoubtedly result from retarded seed development (endosperm failure) but there are indications that cytological barriers do operate during seed germination and seedling growth.

Studies of developing embryos of hyacinth indicate that although there is extensive failure of early zygotes, a number of chromosomally unbalanced forms have not been eliminated sixteen days after pollination (Brock 1955). Subsequent studies indicate that further periods of failure occur both at germination and during early seedling growth. Cytology has so far helped very little in alleviating the difficulties associated with germination and vegetative growth which are physiological as much as cytological, depending as they do not only on the ability to undergo mitosis but also the processes of differentiation. It is possible that inducing polyploidy may restore the balance but this is so far unsupported by practical evidence.

Reproductive Sterility of the Hybrids

A far more common site of operation of sterility barriers in hybrids is during the reproductive phase. Here the genetical and cytological systems of the plant

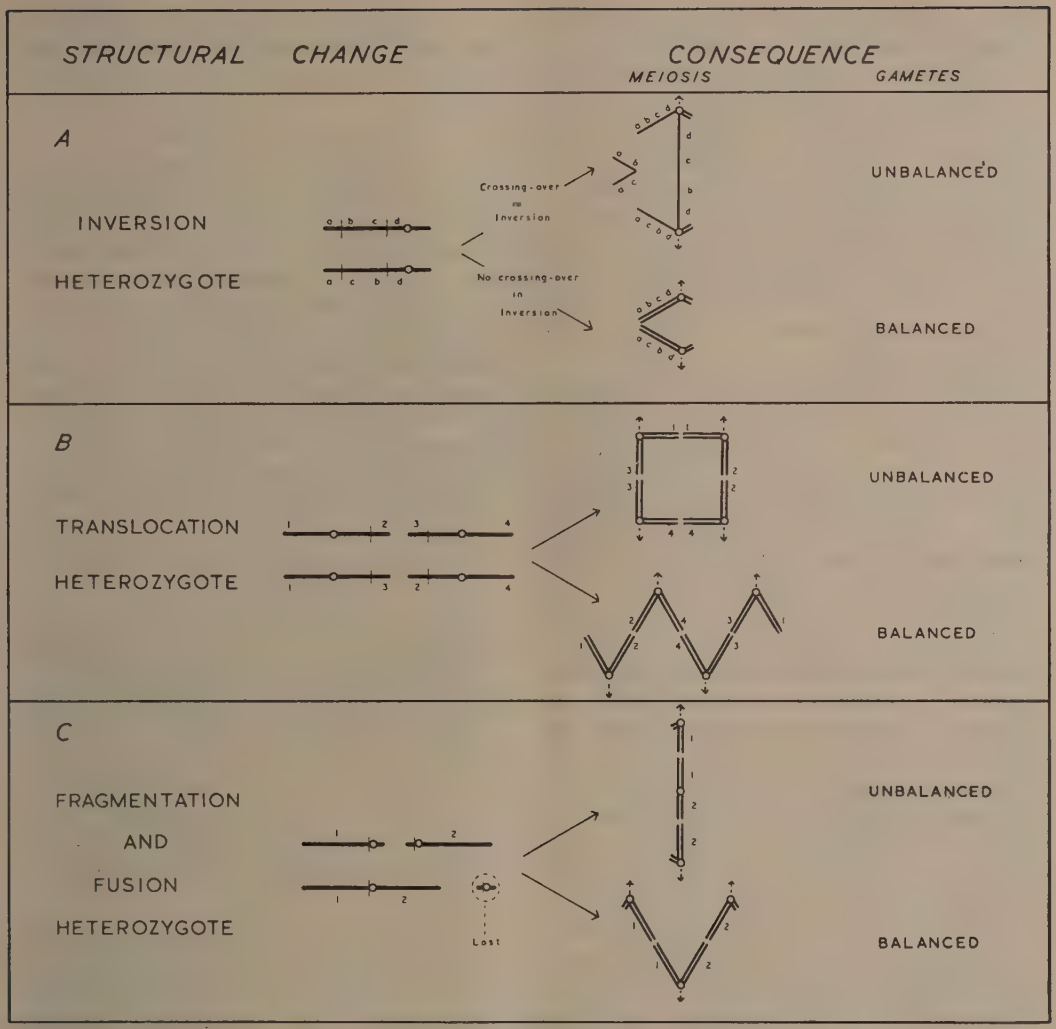

Figure 2.
Structural chromosomal changes.

are subjected to the stresses of meiosis and the segregating products have to exist in the gametophytic phase. At this time numerical, structural and genic unbalances are readily revealed.

Numerical Unbalance

Numerical unbalance occurs in plants produced by the union of gametes of different chromosome number. At meiosis in such plants there are pairing abnormalities and univalents or multivalents are formed which result in numerically unbalanced gametes. As we have seen, such gametes are usually inviable or produce inviable zygotes so that reduced fertility results.

Structural Unbalance

Structural hybrids result from the union of gametes with dissimilar chromosome structures. These structural differences may take a number of forms (Fig. 2). Chromosome breakage and reunion has

played a significant role in the evolution of species and this has resulted in rearrangements of the chromosomal material. Part of a chromosome arm can become inverted with respect to the rest of the chromosome arm so that the linear order of the genes or pairing segments is reversed. Crossing over in this region produces a chromatid bridge and a fragment. Anaphase separation results in breakage of the chromatid bridge and the broken chromosomes pass into the gametes (Fig. 2a).

Portions of chromosomes may become translocated to other chromosomes or there may be an exchange of terminal segments (interchange). At meiosis these result in chains or rings of chromosomes. Separation of such multivalent formations is usually but not always numerically balanced. The type of orientation determines whether the products of meiosis are genically balanced or unbalanced (Fig. 2b). In *Oenothera*, the controlled orientation of multivalents resulting from reciprocal translocation has been adapted to produce a permanent system of hybridity which makes use of the benefits of hybridity (heterosis) without the disadvantage of reduced fertility resulting from unbalanced gametes.

A third type of structural change results in a reduction in chromosome number (Fig. 2c). The new form will only persist where this reduction in number has been achieved with no loss of essential genetic material. It has been suggested that the 12 chromosome forms of *Trifolium subterraneum* arose in this way from those with 16 chromosomes (Brock 1953a). Hybrids have not been obtained between these forms so this cannot be regarded as proven.

Where such forms do hybridize the type of metaphase configuration determines whether the gametes are balanced or unbalanced (Fig. 2c).

Reduction of fertility due to structural hybridity can be alleviated by doubling the chromosome number of the hybrid. This produces two sets of completely homologous chromosomes which are able to pair normally and thus fertility is restored.

Genic Unbalance

Genic unbalance is of undoubted importance in producing reproductive sterility, however only rarely are such cases cytologically detectable. Genes are known which produce asynapsis (failure of pairing); which affect the frequency and distribution of chiasma formation; and which produce abnormalities in spindle and wall formation. These will not be discussed in detail here for they are seldom encountered by the plant breeder. No information is available as to the effects of polyploidy on such abnormalities.

Errors of Synchronization and Differentiation

Further errors can arise during the gametophytic stages. In the development of pollen grains the first mitotic division (pollen grain mitosis) normally produces a generative and a vegetative nucleus. This differentiation is controlled by a cytoplasmic gradient in the pollen grain (La Cour 1949) which is sometimes upset in hybrids resulting in failure of differentiation and consequently pollen abnormalities.

The embryo sac development in *Lilium* hybrids provides a good example of the effect of hybridity on differentiation and synchronization. In *Lilium* all four megaspores (the products of the meiotic divisions) take part in the embryo sac formation (Fig. 3). One of these haploid megaspores migrates from the micropylar to the chalazal end of the embryo sac. At the next mitosis the remaining micropylar nucleus divides, at the same time the three chalazal nuclei form a common spindle and produce two triploid nuclei. One more mitosis produces four haploid and four triploid nuclei. The haploid nuclei form the egg, two synergids and one polar nucleus. The triploid nuclei form the other polar nuclei and the antipodals.

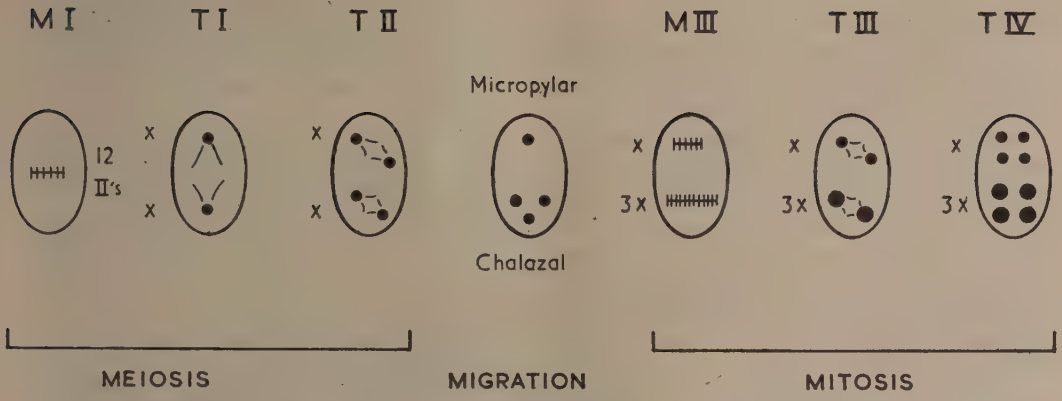

Figure 3.
Embryo sac development in *Lilium* (Fritillaria Type).

Thus the development of the normal *Lilium* embryo sac is dependent on the migration of one nucleus from the micropylar to the chalazal end of the embryo sac and on the synchronization of mitoses in the three basal nuclei. In hybrids these processes are frequently upset. Two tetraploid, four diploid, or four haploid plus two diploid nuclei are frequently formed, instead of four haploid and four triploid (Brock 1954b).

Effect on Seed Setting

It is notable that because of the production of excess pollen, reductions in pollen fertility, unless they are extreme, will have very little direct effect on fertility as measured by seed setting after selfing. However, abnormalities in the embryo sac have a direct effect on seed setting. It is therefore not surprising to find that several mechanisms have been evolved which tend to alleviate the effect of sterility barriers in the embryo sac. In approximately 85% of the angiosperms embryo sac development is monosporic; one of the four megaspores develops to form the embyo sac, the other three degenerate. In most species a specific megaspore always develops, either the micropylar or the chalazal. However in *Oenothera* a mechanism known as the Renner effect operates. The microplyar megaspore normally develops into the embryo sac but if it is inviable it can be replaced by the chalazal megaspore.

In other plants, e.g. subterranean clover, two ovules are formed in each ovary—one of these normally develops and suppresses the other (Aitken and Drake 1941). In the event of sterility in one ovule the other is able to continue growth and develop into a seed.

These, however, are adaptive mechanisms of the particular plant species and are not techniques or methods that can be used at the will of the experimentalist. Consequently they are of little use in overcoming sterility barriers in plant breeding programmes.

Some idea of the relative importance of the various types of sterility can be seen from two examples. In *Lilium* hybrids which have structural hybridity in the form of inversions, the observed cytological abnormalities in pollen mother cells accounted for all the reduced pollen fertility in two of the five crosses studied, and from 56 per cent. to 70 per cent. in the other crosses. Similar meiotic abnormalities occurred in the embryo sac and the level of embryo sac sterility was similar to that of pollen sterility. Although none of these hybrids showed more than 60% pollen or embryo sac sterility, the seed setting after selfing was found to be less than 5% in all crosses (Brock 1954b). Thus, although the meiotic ab-

normalities were contributing quite largely to the pollen and embryo sac sterility the main cause of reduced seed setting was failure of ovules after fertilization.

Some subterranean clover hybrids are also structural hybrids with translocations and some failure of pairing. The contribution of the observed meiotic abnormalities to the pollen sterility is here less than 35% in the four hybrids examined, indicating that genic sterility is playing the major role (Morley *et al.* 1955).

In conclusion I think that the methods and techniques outlined in this review justify the claim that cytology has already made significant contributions to greater efficiency in plant breeding. Even greater contributions will follow the more widespread use of interspecific and intergeneric hybridization, and greater attention to radiation and chemically induced mutations as means of increasing variability. The modern plant breeder already recognises many of the symptoms of failure of the different processes and applies the appropriate technique to alleviate the difficulty. There is, however, need for more research into and greater use of some of the recently developed techniques such as embryo culture.

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FARMING EFFICIENCY ON SOME WHEAT AND DAIRY FARMS IN VICTORIA

By I. MOLNAR

During the course of erosion-production surveys in the Northern Mallee in 1954, and in the Coleraine district in 1955, it was necessary to obtain, along with other data, some information on a number of farming practices. The great discrepancy between some of the practices followed by a large number of farmers and those advocated by the Government Departments and used by the most successful farmers indicates a wide field for further extension work.

These farming practices are discussed in this paper on the basis on interviews made on 51 farms, taken at random, within the Tyrrell-West Stock and Domestic Water Supply District in the Northern Mallee (about 1,500 sq. miles), and on 31 farms in the Coleraine area. The 31 farms around Coleraine are located within the area of 70 sq. miles mapped by Blackburn and Leslie (1949) in their survey of soils and erosion. These farms were practically all the farms in the area which had more than 10 milking cows.

The 53 farms in the Northern Mallee had a total cleared area of 91,093 acres, while the 31 farms around Coleraine covered 8,014 acres. The size of the farms, as managerial units, varied in the Northern Mallee between 628 and 4,300 acres, and in the Coleraine area between 88 and 583 acres. In the latter area only one-third of the 31 farmers were depending entirely on dairying, the others carried also commercial sheep flocks. In 1954-55 the average number of milking cows per herd exceeded 19 on 84 per cent. of the farms.

Practices on wheat farms in relation to local experiments

Application of superphosphate on wheat sown on fallow (1952-1953 av.)

Experiments carried out at the Mallee Research Station, Walpeup, over a period of eight years, show that the increase in wheat yield obtained from an application of 60 lb. superphosphate per acre is 1.9 bush. of wheat, and that from a 90 lb. superphosphate application is 2.4 bush. (Guide Book to the Mallee Research Station, 1955.) These findings can be contrasted with the practices followed by farmers in the district.

Of the 53 farmers interviewed 76 per cent. were using less than 60 lb. superphosphate, and 3 per cent. 90 lb. or more. This state of affairs has to be viewed in conjunction with the fact that with prevailing superphosphate and wheat prices an increase in superphosphate application of twenty pounds per acre is recouped if the resultant increase in wheat yields is of the order of $\frac{1}{4}$ bushel per acre. The relatively small amounts of increase in wheat yields from the application of increased quantities of superphosphate could not be assessed by eye. At the same time guide books and field days publicising locally carried out experiments have been readily accessible to the farmers in the district.

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Application of superphosphate on oats sown on wheat stubble (1952-1953 *av.*)

The result of experiments over a six-year period at Walpeup indicates that 30 lb. superphosphate per acre increases oaten hay yields by 1 cwt. per acre. (Guide Book to the Mallee Research Station, 1955.)

Because of the relatively low amount of superphosphate application by farmers to wheat, the residual superphosphate effect on the following oat crop is likely to be correspondingly low. Despite this, 75 per cent. of the 53 farmers interviewed did not use superphosphate at all with oats and only 9 per cent. used it at a rate of 30 lb. or more per acre.

Time of sowing wheat on fallow (*1954*)

In the Northern Mallee sand dunes usually occupy substantial areas in practically every paddock. The separation by fencing of the dunes with light sandy soils from the relatively heavier flats is impracticable both for economic reasons and because it would hinder the large-sized implements used in this area. Nevertheless, the sowing of the lighter soils before the sowing of the flats is not regarded as providing any difficulty or loss of time worth consideration.

Separate sowing of the dunes some weeks before the sowing of the flats is needed in most years because the relatively early sowing will enable adequate germination before the lighter textured soils get too cold. Thus a wheat crop sown early on the dunes will germinate satisfactorily and will withstand sand blasting by wind better than late sown crops would. This can often mean the difference between success and complete failure.

Figure 1.
Rye along stock and domestic water supply channel with wheat on upper part of high sand dunes.

On interviewing the farmers it was found, however, that only 34 per cent. of them sowed their wheat crop on the hills first. The others had sown the flats and dunes simultaneously.

Practices on wheat farms in relation to local farming experience

Type of implements used on fallow after the initial ploughing (*1953-1954 season*)

It is generally recognised that more wind erosion damage is likely to result from "working of the fallow" on the lighter textured soils of the dunes than on the relatively heavier soils of the flats. For the prevention of serious "blowing" the number of cultivations need to be kept at a minimum, especially so on the dunes. There is also ample evidence available to support the view that disc implements, even if driven at moderate speeds, because of increased pulverisation, make the soil much more susceptible to wind erosion than if tyne implements are used. Although heavy stubbles do demand the usage of discs for the initial ploughing of the fallow, their usage is seldom needed for the control of weed growth later in the summer.

Of the 53 surveyed farms the type of implements used for working the fallow after harvest (i.e., after the initial ploughing of the stubble) was available for 45 farms only. On 33 per cent. of these 45 farms disc implements were used only for the after-harvest working of the fallow, and on 15 per cent. of the farms both disc and tyne implements were used.

Speed at which cultivation implements are used (*1953-1954 season*)

One has to bear in mind that the condition of the ground at the time of a given operation will play an important part in the choice of speed at which implements should be used. Nevertheless, it can be safely stated that for existing

Figure 2.
Landscape near Coleraine. River flats and sloping ground are used for dairying or mixed farming. Tablelands for sheep grazing.

cultivation implements, excepting the mouldboard plough, speeds exceeding 4½ miles per hour will seriously enhance wind erosion in the Northern Mallee due to increased pulverisation, even when soil conditions are favourable for a given operation. It is also generally recognised that relatively fast working will cause less wind erosion damage to the flats than to the sand dunes.

The findings show that on 68 per cent. of the 53 farms all the cultivation implements were used at the same speed on the dunes as on the flats. Table I shows that the situation is much the same if the 53 farms are analysed in more detail.

TABLE I.

Showing number of farmers using various cultivation implements, and the percentage of farmers using these implements at 5 miles/hour or greater speed in the 1953-1954 season.

(Note.—More than one implement was often used by the same farmer.)

Type of Implement	Number of farmers using implement on:		Per cent. of farmers using implement at 5 miles/hour or greater speeds on:	
	Flats	Sand Dunes	Flats	Sand Dunes
Mouldboard ..	5	4	60	50
Tyne	34	33	44	42
Disc, other than tandem	32	31	47	52
Tandem disc ..	11	9	27	33

Practices on dairy farms in the light of non-local experiments

Many breeding and feeding experiments can be regarded as applicable to dairy farming in most districts.

Breeding practices (1955)

On 34 per cent. of the 31 farms surveyed around Coleraine the bull was selected purely on appearance or on reputation of the breeder. Only on 36 per cent. of the farms did farmers examine the production records of the bull's dam and sisters before purchase.

The selection of cows for herd replacement was equally haphazard. On only 39 per cent. of the farms were herds tested, and on 43 per cent. of the farms selection was based on "personal judgment". Shortage of herd testers is unlikely to be the main reason for the low number of herds tested.

Feeding and fodder conservation practices (1954-1955 av.)

Generally, 2 tons of hay per year is the recommendation per dairy cow per year, including the requirements of growing stock in the herd.

It was found, however, that on 48 per cent. of the farms the amount of hay fed out to the herd was about one ton or less, and only on 16 per cent. of the farms was the amount two tons or more, but the low amount of hay used was not compensated by feeding of concentrates. Feeding of concentrates (oaten grain, bran and pollard) was practised on only 44 per cent. of the farms and then at a low level. On 19 per cent. of the farms the feeding was at a rate of 2 bags or less per cow per year, and on 13 per cent. 3 to 4 bags. On 29 per cent. of the farms were fodder crops such as lucerne, chou mollier, rape or turnips grown, and silage was made on one farm only. Thus, little attempt was made to extend the lactation period.

For night grazing of the cows, one or more special night paddocks were used on 55 per cent. of the farms.

Subdivision of the farms was also inadequate. On 29 per cent. of the farms control of grazing management was limited by lack of adequate fencing or water supply to 3 or less separate grazing areas, and on another 22 per cent. of farms there were only 4 or 5 such areas.

On many farms because of the steepness of the land hay making had to be confined to portions of the farm. This can, however, hardly account for cutting meadow hay successively in three years, 1953 to 1955, on the same land on 62 per cent. of the 21 farms which produced hay in each of these years.

Discussion and Conclusion

Many of the farming practices used by a substantial number of farmers interviewed indicate either ignorance of, or indifference to more efficient methods. Outstanding examples are on wheat farms the sowing of wheat simultaneously on the sand dunes and flats, using disc implements on the sand dunes at excessive speeds, and using tandem discs. On the dairy farms, practices which could be put into a corresponding class with the preceding ones are the selection of bulls by the reputation of the breeder, the selection of animals for herd replacement by "personal judgment", the low rate of hand feeding and the using of paddocks exclusively for night grazing.

The use of some other practices could possibly be ascribed to lack of adequate capital. The capital requirements for increased usage of superphosphate on the wheat farms or more fodder conservation on the dairy farms could perhaps come under this heading. Lack of adequate capital is more likely to explain inadequate subdivision of the dairy farms, and inadequate watering facilities on both dairy and wheat farms.

When competition becomes the keynote of overseas marketing more efficient production is the most obvious remedy for the situation. There must obviously be ample scope for increasing efficiency when in a fertile district such as Coleraine, during seasons which are not abnormal, one finds 29 per cent. of the farms producing on the average (1954-1955) about 120 to 140 lb. of butterfat per cow per year, and a further 10 per cent. only reaching 160 lb. and no herd achieves even the Victorian average production.

Acknowledgment

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ACCESSIONS OF NITROGEN (AMMONIA, NITRATE AND NITRITE) IN WESTERN AUSTRALIAN WHEAT BELT RAINS

By D. P. DROVER and I. P. BARRETT-LENNARD

Summary

Analyses of rainwater for five inland stations and one coastal centre in Western Australia, for the four-year period 1952-55 inclusive, showed that the total amount of inorganic nitrogen (ammonia, nitrate and nitrite) gained to the soil was between 0.6 and 3.7 lb /acre/year. The magnitude of these gains showed no significant relation to total rainfall or to locality.

Ammonia was generally the principal nitrogenous constituent of the rainfall of the five inland centres but for the coastal station nitrate predominated.

The total amounts of nitrogen are lower than most of those reported from other parts of the world, and are regarded as insignificant for crop growth.

Introduction

In recent years the question of the importance of nitrogen accessions in natural precipitation to soil fertility has been revived. Ingham (1950) in South Africa claims that 9.5 lb N/acre/year may be added to the soil by the rain and further additions of atmospheric nitrogen may occur from other non-biological sources. In Spain, Tames, Aguirre and Peral (1952) reported that 13.8 lb N/acre/year were found in the rain. Accessions of this order could be of some benefit to the nitrogen balance of arable soils, particularly in dry climates. The extensive early literature on this subject has been reviewed by Miller (1913) and later by Eriksson (1952) and Barrett-Lennard (1953). With the exception of a very few records, such as those cited above, the amounts of combined nitrogen in rainwater have mostly been of a lower order, over a wide range of climates.

The present study of the nitrogen content of rainwater was part of a wider investigation into the nitrogen balance of West Australian wheat soils. In addition, the project was partly complementary to a lysimeter installation at Muresk (Drover 1954). Several lysimeter studies in other parts of the world have been accompanied by rainwater analyses, these include those of Miller (1905), Russell and Richards (1919), Wilson (1921, 1926), Collinson and Mensching (1932) and Chapman, Liebig and Rayner (1949).

Attempts to draw up a theoretical balance sheet for nitrogen in Australian wheat soils (Jensen 1940; Purchase, Vincent and Ward 1949) have included the nitrogen content of rainfall as found by Brunnich (*cit.* Miller 1913). Brunnich analysed water collected at Cairns and Roma in Queensland during 1908. 75 in. and 26 in. of rain were received at these two sites and the quantities of nitrogen ($NO_3 + NH_3$) deposited were 3.13 and 3.71 lb/acre respectively. There appear to have been no subsequent published Australian data. However, the type of weather system and the amount of oxidised nitrogen compounds in the precipitation have been investigated most extensively in Australia by Anderson (1914, 1915) and Masson, Anderson *et al.* (1915, 1916).

Materials and Methods

Localities

During April and May, 1952, with the cooperation of the State Department of Agriculture, rain collection units were installed at the following six localities:—

(i) Chapman Research Station, 350 miles north of Perth.

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(ii) Avondale Research Station, 70 miles south east of Perth, near Beverley.
(iii) Merredin Research Station, 160 miles east of Perth.
(iv) Wongan Hills Research Station, 120 miles north east of Perth.
(v) Muresk Agricultural College, 60 miles east of Perth.
(vi) University of Western Australia, Nedlands, 4 miles west of Perth.

Collection Methods

Rain water was collected in 21 bottles coated externally with black paint and housed in wooden cabinets. A 6-in. glass funnel led into each bottle and wires were erected about its periphery to prevent birds from alighting and contaminating samples. The top of the funnel was about 3 ft. 6 in. above ground level. Plugs of glass wool were used after Masson, Anderson *et al* (1916) to retain large dust particles and other sub-atmospheric contaminants.

Microbiological activity in the water sample was prevented by the addition of 0.1 g mercuric chloride prior to collection. Evaporation was prevented by addition of 0.5 in. of paraffin oil to the bottle; its presence also effectively retained dust and small insects which would otherwise contaminate the sample.

Collection bottles were changed on the first day of each month, placed in a rubber lined wooden box and railed to Perth for analysis.

Analytical Methods

Ammonia, nitrate and nitrite nitrogen were determined on each monthly water sample. Cloudy samples were treated with aluminium sulphate and filtered prior to analysis. All results are expressed on an elemental (N) basis.

(i) *Ammonia.* The tentative magnesium oxide distillation method of Piper (private communication) was used. The liberated ammonia is estimated by addition of Nessler's Reagent to the distillate. After two hours the yellow colour was estimated in a Unicam spectrophotometer, Model S.P. 350, at 420 mμ. *Ammonia-free water was used for all dilutions.*

The only modification introduced was to reduce the amount of magnesium oxide from 2.5 g to about 0.5 g as the larger amount caused turbidities in the distillate in spite of an efficient splash head.

(ii) *Nitrate.* The method of Piper and Lewis (unpublished) was adopted. Essentially, the method involves the nitration of 3:4,xylen-1-ol in (5 + 1) sulphuric acid and unknown solution and steam distillation of the nitrated xylenol into 0.2 N sodium hydroxide. The yellow coloured complex formed was estimated in a spectrophotometer at 430 mμ after two hours. The procedure is very sensitive, detecting from 0-150 micrograms of nitrate with accuracy.

Chlorides interfere with the nitration and these were eliminated by adding 0.5 g NO_3-free silver sulphate/litre of (5 + 1) sulphuric acid.

(iii) *Nitrite.* The method of Treadwell and Hall (1935) was adopted using sulphanilic acid and alpha naphthylamine in the presence of acetic acid. The pink coloration developed in the presence of nitrites was estimated in a spectrophotometer at 510 mμ after 10 minutes.

Results and Discussion

The 1952, 1953, 1954 and 1955 accessions of nitrogen in rainwater at the six stations are shown in Table I. The amounts of nitrogen are very small, ranging from 0.6 to 3.7 lb/acre/year.

All the collection stations, including the coastal station of Nedlands, were remote from contamination from industrial and town sources so that the figures probably represent natural accessions of nitrogen compounds. With the exception of Nedlands, all collection sites were in agricultural regions. Although contamination could occur from dust during the drier summer months little evidence of such contamination was observed. Where substantial contamination did occur through dust, pollen or insects the sample was either not analysed for ammonia or dis-

TABLE I.

Quantity of ammonia, nitrate and nitrite nitrogen in rainwater 1952-1955—lb/acre.*

Locality	NH_3-N	NO_3-N	NO_2-N	Total	% NH_3-N	Rain Analysed (inches)	Total Rain (inches)
Nedlands							
1952	0.336	0.387	0.030	0.753	44.6	31.51	36.12
1953†	0.627	0.858	0.021	1.506	41.6	33.49	33.49
1954‡	0.739	1.207	0.030	1.976	37.4	28.06	28.19
1955	2.533	1.136	0.070	3.739	67.8	45.15	45.15
Avondale							
1952	0.296	0.295	0.007	0.598	49.5	13.24	15.46
1953	1.284	0.197	0.016	2.217	57.9	16.46	16.46
1954	0.600	1.080	0.008	1.688	35.5	10.33	10.69
1955	2.057	0.689	0.013	2.759	74.6	22.32§	21.96
Chapman							
1952	0.469	0.216	0.007	0.692	67.8	10.99	11.75
1953	2.099	0.618	0.020	2.737	76.7	18.90	18.90
1954	2.027	0.642	0.044	2.713	74.7	11.53	11.53
1955	2.441	0.711	0.045	3.197	76.4	18.59	23.64
Merredin							
1952	0.418	0.388	0.053	0.859	48.7	7.35	9.09
1953	1.189	0.400	0.044	1.633	72.8	15.13	15.13
1954**	1.363	0.208	0.001	1.572	86.7	4.83	9.22
1955††	0.367	0.204	0.013	0.584	62.8	8.19	13.20
Muresk							
1952	1.143	0.274	0.012	1.429	80.0	14.37	18.76
1953‡‡	0.706	0.388	0.008	1.102	64.1	21.99	21.99
1954	0.558	0.627	0.012	1.197	46.6	13.28	13.82
1955	0.756	0.837	0.042	1.635	46.2	27.38	28.28
Wongan Hills							
1952	0.438	0.226	0.003	0.667	65.7	9.53	9.93
1953	0.621	0.466	0.011	1.098	56.6	16.80	16.80
1954	0.839	0.270	0.004	1.113	75.4	8.35	8.73
1955	0.574	0.702	0.021	1.297	44.3	16.15	18.06

* NH_3, NO_3, NO_2 expressed on an elemental (N) basis.
† Sept., Oct. NH_3 excluded, contamination.
‡ Nov. NH_3 excluded, insufficient sample.
§ Inclusive from 1st Oct., 1954.
** July omitted, contamination.
†† Jan.-April, Nov. omitted, contamination by birds, and funnel removed.
‡‡ Sept., Oct., Nov. NH_3 omitted, insufficient sample.
All analyses from monthly samplings.

carded depending on the degree of contamination.

The proportion of ammonia nitrogen in the total amount of nitrogenous compounds is variable at each station and between stations. All the data reviewed by Miller (1905) for temperate localities show that ammonia is the principal constituent and usually comprises more than 60% of the total nitrogen. Angstrom and Hogberg (1952) in Sweden have shown that the ratio of NH_3:NO_3 nitrogen is almost invariably 2.0 The data presented here do not support these findings. At Nedlands, except for the 1955 data, the proportion of ammonia nitrogen was below 50%. This is in accord with Miller (1913) who found that coastal stations

had a lower ammonia content than inland ones.

The variability of the nitrogen content between years at each station is interesting in relation to the possible sources of nitrogenous compounds. These fall into two groups according to their origin.

(i) Cyclic nitrogen compounds—dust, ammonia, nitrate and nitrite having its origin in the ocean or soil. Obviously such compounds are not new accessions to the soil but merely redistributed ones.

(ii) Noncyclic nitrogen compounds—these may arise by photochemical oxidation of nitrogen in the ozonosphere (Virtanen 1952) and represent new accessions to the soil.

The relatively stable rain-bearing systems in Western Australia are mainly of winter occurrence and arise from the Indian Ocean. Because of their stability and regular incidence some correlation between rainfall and its nitrogen content would therefore be expected. One of the reasons why this is not found may be the variable occurrence of contaminating substances (dust, pollen) and other cyclic nitrogen compounds.

In general the total nitrogen content of West Australian rain is lower than that recorded for most overseas localities which usually report amounts greater than 5 lb/acre/year. Such localities are of relatively high rainfall. An exception is provided by the work of Chapman, Liebig and Rayner (*loc. cit.*) who obtained 0.53 lb/nitrogen/acre/year under 12.98 inches annual rainfall in California. Although their locality is similar in rainfall to most of the stations in Western Australia the total nitrogen contents reported here are all greater and in most cases very much greater than theirs. Further, the annual accession of nitrogen from West Australian rain is less than that found by Brunnich in Queensland, although it must be mentioned that his total rainfall was considerably greater and his analyses covered only one year.

It is clear that the nitrogen content of West Australian wheatbelt rains is too low to be of consequence in the growth of crops and the nitrogen balance of arable soils.

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BOOK REVIEWS

THE WHEAT INDUSTRY IN AUSTRALIA

By A. R. CALLAGHAN and A. J. MILLINGTON

(*Angus and Robertson*, 1956, 63/-.)

Wheat ranks second only to wool amongst the primary industries of Australia, is grown by some 60,000 farmers in all States of the Commonwealth, was valued at over £100,000,000 per annum for crops grown in recent years, requires the production of many secondary industries and extensive aid of public utilities, engages the attention of a considerable (though insufficient) number of scientific and technical workers, and is not without political significance. Nevertheless, it is a fact that this book is the first comprehensive account of the Australian wheat industry.

The authors have performed an immense task by the compilation of such a review of every facet of wheat production and marketing. It is probable that this monograph will for years remain an outstanding text and reference book for students, research workers and specialists, and be read also by many wheat-growers interested in the overall picture of the wheat industry in Australia. Its historical, descriptive, social and philosophical sections will require no amendments when the dated discussions are due for revision.

The outstanding theme of this book, designed to stimulate action, is that concerned with the maintenance of soil fertility—the development of a permanent agriculture. Current agricultural scientific literature abounds with discussions on this vital subject, but how regrettably sparse is the field data available to assist extension workers in their efforts to translate principles into practice!

The authors describe and refer frequently to the diverse characteristics of the Australian wheat belt environment—soils, rainfall, size of farms, etc., but highlight the many common factors. Foremost is the need to make maximum use of legumes for the accumulation of soil nitrogen and organic matter in the pasture phase of the rotation with a view to lifting both yield per acre and baking quality of the grain. This wide subject, in all its aspects, is extensively discussed, although the immediate cost consideration is but briefly mentioned. No angle of wheat-growing appears to be omitted. Outstanding of twenty-seven chapters are those concerned with the many wheatland soil types of Australia; the concept of varieties and the work and opportunities of the plant breeders; power and the farmer; economics and the farmer; world trade in wheat.

Regarding the future, and having in mind the record world stocks of wheat, the authors somewhat tentatively state—"the longer term outlook for Australian wheat is reasonably secure at prices somewhat lower than present levels." The reviewer would have been more optimistic in the long term; the short term presents the problem.

The F.A.Q. standard receives its inevitable criticism, with constructive alternatives given but still to be costed. The book is completed with an important chapter entitled "The farmer and his technical advisers," in which the personal views of the authors come to the fore. Although one or other of the authors has evidently read practically, if not all, the pertinent literature extant, only some could be selected for specific quotation. However, the bibliography includes citations from the published work of over one hundred scientists and wheat agronomists, of whom 75 per cent, are Australian.

As might be expected by the authorship, the history, performance and problems of the wheat industry are discussed somewhat more fully for South Australia and Western Australia than for the eastern States, but sufficient references are given for any wheat agronomist to pursue his investigations in relation to specific areas.

Extensive use is made of statistics, mainly by graphs, diagrams and maps, and the book contains a splendid collection of illustrative photographs. There is also a very full index.

The reader will find the book interesting, informative, stimulating, and worthy of the great Australian wheat industry, which has experienced its victories, but has many problems still to be worked out with the assistance of scientifically trained wheat agronomists.

W. B. MILLER.

THE INFLUENCE OF FUNGICIDES AND FRUIT MATURITY ON THE DEVELOPMENT OF RIPE SPOT AND TARGET ROT OF APPLES

By G. C. WADE and J. R. WARD

Summary

A lime sulphur-colloidal sulphur schedule was shown to give no significant control of ripe spot of apples. Substitution of thiram or captan for early season applications gave very good control at picking time. However, additional later applications were required before control of the disease in storage was obtained. While the fungicide may exert control by directly preventing infection, it is suggested as an alternative explanation that the fungicides delay maturity changes in the fruit which render the fruit susceptible to the extension of latent infection. Early picking greatly reduces losses in cold storage, but the reduction in incidence in common storage is less marked. It is suggested that cold storage delays maturity changes affecting fruit susceptibility.

Introduction

In an earlier paper (Wade, 1953) it was stated that infection with a species of *Gloeosporium* responsible for ripe spot and target rot of Sturmer apples in Tasmania apparently occurred early in the development of the fruit, but remained latent until the fruit matured. Further experiments have now been conducted with the objective of determining more precisely when infection occurs, and the results will be reported in this paper.

It was also indicated that if the fruit are picked early subsequent loss from the disease is reduced, and experimental evidence for that statement is presented.

At the time of writing the previous paper the exact identity of the organism responsible for the disease was in doubt. It has now been identified by the Commonwealth Mycological Institute as *Gloeosporium album* Osterw.

Control by Fungicides

In earlier work it was shown that thiram (Tetra methyl thiuram disulphide) and captan (N-trichloromethyl-thio-tetra hydrophthalimide) gave better control than any other materials tested, while dichlone (2:3 dichlora 1:4 naphthoquinone), ferbam (ferric dimethyl thiocarbomate), lime sulphur and Crag C (mixed glyoxalidines) gave more control than a lime sulphur-colloidal sulphur schedule (Wade 1953). Further work with some of those fungicides and with other materials was conducted in the 1952-53 and 1953-54 seasons.

Experiment in 1952-53

Six spray schedules were tested with 4 replicates of each treatment. All trees except A received a spray of 6:4:40 Bordeaux mixture at the green tip stage. The sprays were applied with a portable pump and using a pressure of approximately 250 lbs/sq. in. The fruit were picked on the 5th and 6th of May and the number showing ripe spot determined. The experiment was carried out on the property of Mr. F. M. Clark, Franklin.

The results which are tabulated in Table I demonstrate that a lime sulphur-colloidal sulphur schedule does not provide any control of the disease. T.M.T.D. and Captan provided an equal measure of control, the results being better when the materials were used for all sprays than when they were applied at the calyx and first cover stages only.

Experiment in 1953-54

Ten spray schedules were tested with 5 replicates of each treatment. All trees received a green tip application of 6:4:40 Bordeaux. "Black Jack" was prepared by mixing 1 gallon of lime sulphur and 3 lbs of sulphate of iron in 50 gallons of

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TABLE I.

Incidence of ripe spot of apples in Franklin experiment.

Sprays Applied				Incidence of ripe spot	
Pink	Calyx	1st Cover	2nd and 3rd Cover	As %	As Arsine $\sqrt{\%}$
Nil	Nil	Nil	Nil	27.4	31.5°
L.S. 1/30	L.S. 1/80	Coll. S.	Coll. S.	26.8	31.2°
L.S. 1/30	T.M.T.D.	T.M.T.D.	Coll. S.	8.6	17.0°
L.S. 1/30	Captan	Captan	Coll. S.	7.7	16.1°
T.M.T.D.	T.M.T.D.	T.M.T.D.	T.M.T.D.	2.1	8.2°
Captan	Captan	Captan	Captan	0.6	4.3°
			Least difference for significance @ 5% level		7.7°
			Least difference for significance @ 1% level		10.6°

water, thiram (T.M.T.D.) and ziram were used at the rate of 1½ lb of 80 per cent. concentrate per 100 gallons, dichlone at ½ lb per 100 gallons, phenyl mercuric fixtan (P.M.F.) at 8 ozs per 100 gallons at pink and 4 ozs/100 gallons thereafter, phenyl mercuric chloride (P.M.C.) at 2 lbs of a 2 per cent. concentrate/100 gallons, "Nirit" (thio cyano dinitro benzene) at 7½ lbs/100 gallons at pink and 5 lbs/100 gallons at calyx and covers, captan at 2 lbs per 100 gallons and "Quintox" (phenanthraquinone) at 2 lbs per 100 gallons.

The experiment, conducted on the property of Mr. R. A. Woodward, Judbury, was designed primarily to test the schedule for black spot control, but the incidence of ripe spot was also assessed. Rating for fruit russet was determined as described previously (Wade 1951).

The results are shown in Table II.

In this experiment "Nirit", dichlone and captan gave significantly poorer control than thiram, while ziram, P.M.F., P.M.C. and "Quintox" gave the same order of control as thiram. Dichlone, ziram, P.M.F., P.M.C., captan and "Quintox" all caused more fruit russet than thiram.

Influence of Time of Fungicide Application on Incidence

The 1952-53 experiment, and experiments described in a previous paper (Wade 1952) suggested that a considerable amount of infection occurred early in the development of the fruit. In 1953/54 an experiment was conducted to determine more precisely when infection occurred, and to find the effect of spray schedules on the development of the disease in storage.

Method

A lime-sulphur-colloidal sulphur schedule had been shown to exert no significant control of the disease. Therefore this was used as the basic schedule and progressive increases in the number of T.M.T.D. applications were made in other schedules. In addition, two schedules were included in which inorganic sulphur fungicides were used for early sprays, but T.M.T.D. substituted for later cover sprays. The experiment was conducted on the property of R. A. Woodward, Judbury. There were five replicates of each treatment.

The fruit were picked and sorted for ripe spot on the 24th and 25th May. One case of sound fruit from each tree was held in a commercial cool store at ap-

TABLE II.

Incidence of ripe spot in Judbury experiment.

Treatment		Incidence of ripe spot		Russet rating	
Pink	Calyx and 3 Covers	As %	As logs	As %	As Arsine √ %
L.S. 1/30	T.M.T.D.	0.2	0.820	19.5	26.2°
"Black Jack"	T.M.T.D.	0.2	0.840	19.9	26.5°
Dichlone	Dichlone	0.6	0.989	23.5	29.0°
T.M.T.D.	T.M.T.D.	0.1	0.787	18.0	25.1°
Ziram	Ziram	0.3	0.876	24.9	29.9°
P.M.F.	P.M.F.	0.4	0.894	31.0	33.8°
P.M.C.	P.M.C.	0.1	0.744	29.2	32.7°
Nirit	Nirit	1.2	1.184	20.3	26.8°
Captan	Captan	0.6	1.026	25.6	30.4°
Quintox	Quintox	0.4	0.895	30.0	33.2°
Least difference for significance at 5% level			0.180		3.7°
Least difference for significance at 1% level			0.241		5.0°

proximately 34°F. for 17 weeks. In order to ensure that the case was representative of all fruit on the tree the procedure adopted if the tree produced four cases was to sample every fourth fruit, if it produced five cases every fifth fruit was sampled, etc. On removal from cool store the fruit was sorted for ripe spot and target rot, and then held at atmospheric temperature for four weeks when the amount of ripe spot and target rot was again determined.

In Table III, which gives the results of this experiment, only the total storage loss is quoted, since the figures for development in cool or common store separately were so variable that statistically significant results could not be demonstrated.

The substitution of T.M.T.D. for lime sulphur at the pink stage resulted in a highly significant reduction in the development of ripe spot on the fruit at picking time, and further applications of

TABLE III.

Influence of time of application of T.M.T.D. on disease development.

Treatment					Ripe spot on tree		Total ripe spot and target rot in storage	
Pink 13/10/53	Calyx 29/10/53	1st Cover 19/11/53	2nd Cover 15/12/53	3rd Cover 12/1/54	As arsine √ %	As %	As arsine √ %	As %
L.S. 1/30	L.S. 1/80	Coll. S.	Coll. S.	Coll. S.	10.44°	3.52	19.9°	11.6
T.M.T.D.	L.S. 1/80	Coll. S.	Coll. S.	Coll. S.	5.82°	1.16	19.8°	11.5
T.M.T.D.	T.M.T.D.	Coll. S.	Coll. S.	Coll. S.	3.00°	0.36	14.1°	5.9
T.M.T.D.	T.M.T.D.	T.M.T.D.	Coll. S.	Coll. S.	2.74°	0.24	14.9°	6.6
T.M.T.D.	T.M.T.D.	T.M.T.D.	T.M.T.D.	Coll. S.	1.72°	0.18	11.2°	3.8
T.M.T.D.	T.M.T.D.	T.M.T.D.	T.M.T.D.	T.M.T.D.	2.74°	0.26	7.0°	1.5
L.S. 1/30	L.S. 1/80	Coll. S.	Coll. S.	T.M.T.D.	7.98°	2.04	20.0°	11.7
L.S. 1/30	L.S. 1/80	Coll. S.	T.M.T.D.	T.M.T.D.	7.54°	2.12	25.9°	19.1
Least difference for significance at 5% level					3.20°		8.0°	
Least difference for significance at 1% level					4.32°		10.8°	

T.M.T.D. did not significantly increase the degree of control of this phase of the disease. However, significant control of ripe spot and target rot in storage was not achieved with this schedule, and it was not obtained unless T.M.T.D. were used at the pink, calyx and 1st and 2nd cover stages. T.M.T.D. used after earlier sprays of inorganic sulphur fungicides did not give control either at picking time or in storage.

Fruit Maturity in Relation to Development of the Disease

Ripe spot on the tree

Observations have previously shown that ripe spot becomes more serious if fruit are left on the tree after they become mature. In the 1952-53 season this was checked experimentally by selecting at random four Sturmer trees which had received a lime sulphur-colloidal sulphur schedule. One case representative of all fruit on the tree was picked from each tree on 15th April, 1953, another case on 5th May, 1953 (the normal picking time in that season) and another on 26th May, 1953. The fruit were sorted for ripe spot.

The results showed that fruit picked on 15th April, 1953, contained 5 per cent. infected with ripe spot, those picked on 5th May, 1953, 16 per cent., and those on 26th May, 1953, 56 per cent.

Development of ripe spot and target rot in storage

It has been stated previously (Wade 1953), on the basis of general observation, that if the fruit is picked early, subsequent development of the disease in storage is much less. This conclusion had also been reached by Cunningham (1942) and Taylor (1946a) for a similar disease of Sturmer apples to *Neofabrae malicortis* (Cordley) Jackson. In 1953-54 an experiment on the development of the disease in storage was conducted.

On 5th May, 1954, one hundred apparently sound fruit were taken at random from each of five Sturmer trees which had been sprayed throughout the season with a sulphur schedule, and on 26th May, 1954, a further one hundred fruit were sampled. Fifty fruit of each lot were stored at room temperature for 10 weeks from the date of picking and sorted for ripe spot and target rot. The other fifty fruit were stored at 34°F. for six months. On removal from store they were sorted, and the remaining sound fruit stored at room temperature for 3 weeks and again sorted.

In Table IV the total loss in fruit cool stored for six months and then for three weeks at room temperature is shown.

TABLE IV.

Relation of picking time to disease development in storage.

Picking date	Percentage ripe rot plus target rot		
	Room temp.	Cool storage 6 months	Cool storage for 6 months plus room temp. 3 wks.
5/5/54	59.6	3.6	8.7
26/5/54 . ..	86.0	16.0	24.2

Thus after six monthe cold storage approximately four times as many fruit from the later picking as from the earlier picking showed infection, and after cold storage for six months followed by three weeks at room temperature approximately three times. If the fruit were stored continuously at room temperature for ten weeks the ratio was 1 to 1.5.

It is of interest to note that the first symptom to develop in storage was a brown circular spot about $\frac{1}{8}$ in. in diameter. The lesions were similar to those of tree ripe spot, but lacked the red halo characteristic of the disease on the tree. These lesions did not develop further for several days, when they rapidly enlarged and the fungus penetrated into the flesh of the fruit, producing a soft brown rot. The skin over the rotted area developed alternate concentric zones of light and dark brown.

Discussion

The results reported show that applications of certain fungicides, such as thiram, early in the season give efficient control

of ripe spot on the tree. However, control of ripe spot and target rot in storage is not achieved unless the applications are continued until much later in the season. Therefore, it is apparent that infection can occur during a considerable period of the season, and it can no longer be concluded, as was done in a previous paper (Wade 1953), that most of the infection occurs about the calyx stage.

No definite explanation of the results reported in Table III can be offered on the basis of the work conducted, and several alternatives seem possible. If thiram owes its effect only to its fungicidal action, latent infections initiated early in the season must differ in some way from those initiated later, so that they are able to enlarge and produce visible lesions more rapidly as the fruit mature, and later infections do not become visible until maturity is more advanced. Without such an assumption there is no reason why thiram at the "pink" only should not give as effective reduction of the disease in storage as it does on the tree at picking time.

Alternatively the action of the effective fungicides may be indirect and delay the development of some factor in fruit maturity which enables latent infections to extend. In order for this explanation to be correct, the substitution of thiram for lime sulphur as early as the pink stage would have to affect the time of development of maturity in the fruit, but later applications would then further retard maturity, so that the effects were maintained throughout the storage period.

Considering the results in Table III alone it might be suggested that lime sulphur and colloidal sulphur advance maturity and an increase in the number of applications of those materials therefore increases the susceptibility of the fruit. However, the results of the experiment reported in Table I did not provide evidence that they increased the susceptibility of the fruit to the disease as compared with unsprayed trees.

New Zealand workers (Taylor 1946 a and b; Jacks 1953) have obtained control of ripe spot in Sturmers, due to the closely related fungus *Neofabraea malicortis*, by summer applications of Bordeaux mixture. It is possible that the life histories of the two fungi may differ and infection may occur at different stages of the season. However, the apparent contradiction between their results and ours would be explained if the main action of the fungicides is by delaying fruit maturity. In Jacks' paper he stated that Bordeaux mixture apparently retarded the maturity of the fruit.

The influence of time of picking on the development of the disease in storage cannot be explained satisfactorily by a change in the time of exposure of the fruit to infection. The results reported here show that if fruit picked at two periods are stored at atmospheric temperature, the late picked fruit only develop 50% more infection than early picked fruit. However, if they are cool stored immediately after picking the difference in development on early and late picked fruit is much greater. This difference is reduced if the fruit are subsequently stored at atmospheric temperature for four weeks. The difference in susceptibility is probably due to maturity differences which are reduced by storage at room temperature and maintained by cool storage. It is apparent that early picking alone is not a satisfactory control of the disease, unless the fruit can be maintained in cool store throughout their storage life.

Acknowledgment

The field work described was conducted on the properties of Mr. F. M. Clark, Franklin, and Mr. R. A. Woodward, Judbury, and thanks are expressed to these growers for making trees available for the work, and for provision of other facilities. Dr. D. Martin, Officer in Charge, C.S.I.R.O., Tasmanian Regional Laboratories, kindly made storage facilities available and gave helpful advice.

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BOOK REVIEWS

AUSTRALIA'S TRADE RELATIONS: AN OUTLINE HISTORY OF AUSTRALIA'S OVERSEAS TRADING ARRANGEMENTS

By D. F. NICHOLSON

(*Cheshires, Melbourne,* 1955, 42/-.)

Despite the impression from a first glance, this book is particularly readable, and upholds the writer's intention which he states in his Preface. Surprisingly, the dry bones of trade negotiation come to life and although far from being even moderately light reading any person with some interest in Australia's trade relations with other countries can find not only a logically told history of our trade arrangements since colonial days, but an insight into the many trade difficulties which have made newspaper headlines in the not so distant past.

The early history of the Australian colonies is dealt with in the first part of the book. In this period the power of the colonies to make their own trade regulations was naturally restricted by the United Kingdom. It is interesting to see that even today Australia could claim trade preferences with countries which signed agreements with Britain in the years when the colonies themselves were not signatories, but, were automatically entitled to benefit as part of the British Empire.

The section dealing with the Ottawa Agreement of 1932 is naturally one of the most important parts of this book. It is discussed in a completely factual manner but the economic pressures which led to its creation as well as the advantages and difficulties which followed it are outlined. Perhaps one disappointing feature of this survey is that no attempt has been made to assess the relative advantages of this Agreement to Australia and the United Kingdom. Commenting on it Nicholson says guardedly "that the balance of advantage would certainly appear to rest with the United Kingdom."

The origins of the General Agreement on Tariffs and Trade are described very fully indeed. Although it began to operate only in 1948, its genesis is to be found in the Atlantic Charter of 1941. It is aimed at allowing a freer flow of world trade through the lowering of existing trade barriers. It is based on the principle of most favoured nation treatment for all goods entering world trade and the strain that this imposes on the principle of British preference is shown in a special chapter.

Apart from the impact of Ottawa and G.A.T.T. on Australia's trade the endless negotiations of each decade are dealt with fully. The description of the difficulties of the years between the depression and the Second World War is one of the most interesting parts of this book. This was the period when British preference tariffs erected by Australia caused a decline in trade with other countries and a trade drive was made to negotiate agreements with European countries wherever possible. It was also the period when cheap Japanese goods were flooding into Australia, and Germany was "dumping" surplus goods in this country.

Mr. Nicholson is an officer of the Department of Trade and Customs and as such could hardly be better qualified to write such a book as this. The ground which he has covered is so obviously in itself worthy of an entire volume that to criticise him for not including additional information seems hardly fair. One would like to see some critical assessment of the effect of Australia's trade policies written on the same high level as this publication. Perhaps the one valid addition which could be suggested to improve this book would be the inclusion of an index indicating the pages which deal with specific commodities. It would be difficult as things stand to trace the trade negotiations which have affected for instance the export of wool or the import of cotton goods. This however is a minor defect and one is grateful that the pioneer work in this field is of such high quality.

L. E. COZENS.

WART DISEASE OF SUBTERRANEAN CLOVER

This disease was discovered on Dwalganup, Yarloop, and Mount Barker varities of subterranean clover at Talbot Brook, Western Australia. It is a first record of the disease in Australia, and on subterranean clover. The disease has been recorded on a number of other species of *Trifolium*, including *T. repens, T. pratense, T. montanum, T. resupinatum, T. incarnatum* and *T. hydridum* in Europe, England, India, Japan, U.S.A. and Canada.

The cause of the disease is the chytrid fungus *Physoderma trifolii* (Passer:) Karling. It was first described by Passerini in 1877 as *Synchytrium trifolii.* Shroeter in 1882 described it as *Olpidium trifolii,* and in 1902 Bubak named the chytrid causing wart on *T. montanum* in Bohemia as *Urophylyctis bohemica,* Magnus later renamed this *U. trifolii.* Karling (1950) revised the genus *Physoderma* and on morphological grounds has shown that the genus *Urophlyctis* should belong to the genus *Physoderma.*

The warts are histoid galls about 5 mm. in diameter and occur on the stems, petioles, and peduncles giving a beaded appearance to these parts. They often coalesce and cause twisting and distortion of the host, see Figure 1.

When sectioned these galls show a

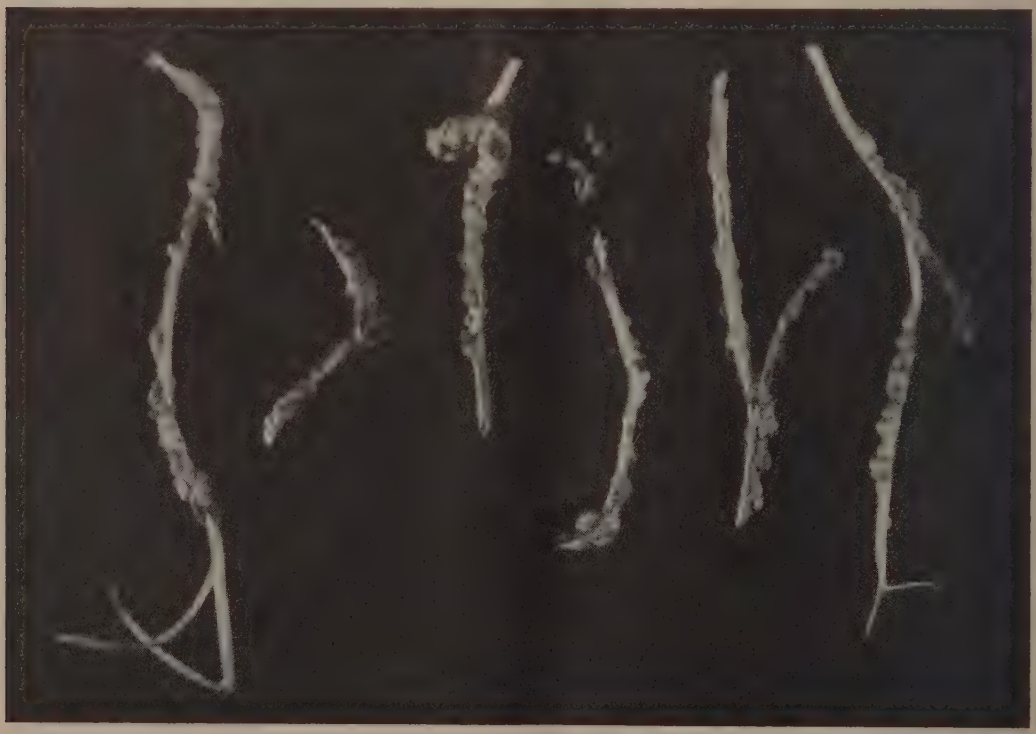

Figure 1.
Warted stems of T. subterraneum; x 1½ n.s.

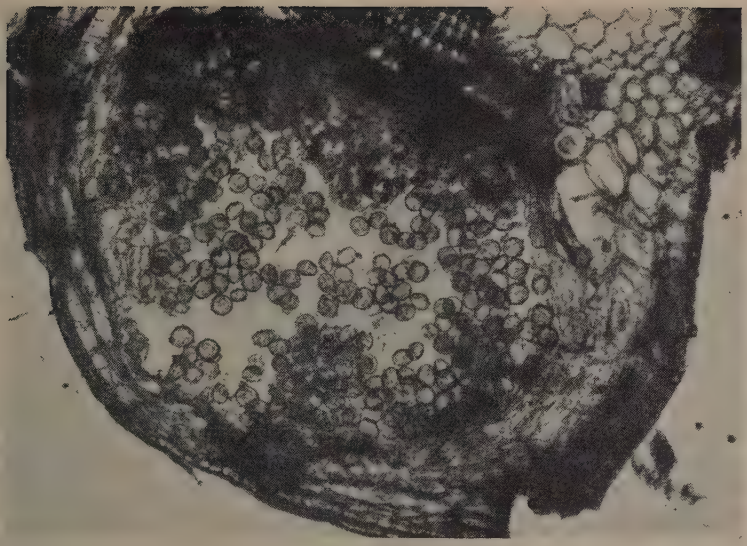

Figure 2.
Section through histoid gall showing resting sporangia of P. trifolii filling hypertrophied host cells; x 75 n.s.

number of hypertrophied host cells containing upwards of 200 golden brown hemispherical resting sporangia of 40-45 microns in diameter, see Figure 2. The hypertrophied cells containing the sporangia are surrounded by a covering of several layers of cortical parenchyma. The resting sporangia are slightly flattened on one side and are surrounded by a ring of pits. So far germination of these sporangia has not been observed though this is being attempted.

Diseases caused by chytrids are usually associated with wet and flooding contions, for example, in crown wart of lucerne (*Physoderma alfalfae*). In the area affected with wart disease of subterranean clover there was an unusually high rainfall in late summer, autumn and spring. Soil saturation occurred at the three worst sites for long periods during late winter and spring. In one sloping area this resulted from constant seepage from higher ground, but the other two were in wet depressions.

The effect of this disease on subterranean clover may be severe, and it is therefore important to discover the conditioning factors for infection since many areas in which subterranean clover is grown in Australia are liable to flooding. It is probable that should the pathogen become widely established, the growing of subterranean clover in low lying areas may be seriously affected.

The discovery of this disease in Australia raises the question of how the inoculum was introduced. It is possible for the inoculum as resting sporangia to be transmitted by seed either as admixed or adherent contaminants of clover seed. The resting sporangia of the chytrids are known to be long lived and very resistant to extremes of temperature and other physical agencies by virtue of their thick endospore.

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A COMPARISON OF TWO FUNGICIDES FOR CONTROL OF DOLLAR SPOT

Dollar spot of turf, caused by *Sclerotinia homoeocarpa* Bennett, occurs annually on fine turfs in the Canberra area and creates a serious maintenance problem. The disease normally makes its appearance during periods of high humidity and moderate temperature (between 70°F. and 85°F.). Recovery is rapid when the weather becomes less favourable for disease development and this factor may lead to a marked variation in the amount of dollar spot present at any one time. Severe damage occurs only when optimum conditions are prolonged. The first occurrence of the disease in Canberra usually takes place during October or November but it rarely becomes serious until late summer or autumn.

The first symptom of the disease is the appearance of mycelial weft in circular areas one to two inches in diameter and is most frequently observed during early morning. Subsequently the grass is killed at the crown and the characteristic brown dollar spots appear. During severe attacks the spots may become contiguous and large areas of turf are affected.

The endemic nature of the disease enabled a comparison to be made between P.A.C.A. (Phenyl-amino-cadmium-acetate), shown to be the most effective treatment under local conditions (Ludbrook and Brockwell 1952), and Actidione* reported as a successful turf fungicide (Vaughn 1951; Vaughn and Klomparens 1952).

The materials were tested at the Royal Canberra Golf Club on a green consisting of creeping bent (*Agrostis tenuis* Sibth.) and Chewings fescue (*Festuca rubra* var. *fallax* Hack.). Treatments were commenced in October, 1953, and continued until March, 1954, except for a period from mid-December to the end of January, when the disease does not normally occur. The experimental area was kept under observation throughout. Dollar spot first appeared on January 26 and followed a normal course for four weeks. Many new infections occurred during the fifth week and the disease reached epidemic proportions. The experiment was continued until March 9, when a routine top dressing was applied and further observations could not be made.

Plots four feet square were laid out on an area of healthy turf. Treatments were replicated ten times and were applied with a garden spray.

The treatments were:—

(a) P.A.C.A.: A 0.1% aqueous solution applied fortnightly at the rate of 50 gals. per 600 sq. yds.

(b) Actidione: As actidione ferrated (0.09g. acidione + 2.16g. ferrous sulphate in 6.72 l. water) applied fortnightly at the rate of 50 gals. per 600 sq. yds. (equivalent to the manufacturer's recommended rate of 0.5 oz. per 1,000 sq. ft.).

(c) Control: Sprayed with tap water fortnightly at the rate of 50 gals. per 600 sq. yds.

Severity of the disease was measured in an area three feet square within the plot, thus providing a buffer zone of two feet between treatments. Each plot was divided into four inch squares and the presence or absence of dollar spot recorded weekly.

*The antibiotic cycloheximide provided by The Upjohn Co., Kalamazoo, Michigan, U.S.A.

TABLE I.

Incidence of dollar spot.
Recorded at weekly intervals from 26/1/54 to 9/3/54 inclusive.

Treatment	Percentage of squares affected						
Control	0.25	0.49	0.62	2.47	16.66	32.47	17.28
Actidione	0.12	0.74	0.62	2.22	12.84	31.98	14.81
P.A.C.A.	0.12	0.25	0.37	1.73	*9.88	25.06	*9.63

*Difference from control significant at 5% level.

The results, expressed as a percentage of affected squares per treatment, are presented in Table I.

Under the conditions of the experiment, actidione caused no reduction in incidence or area affected. While P.A.C.A. caused appreciable reduction, control was not so effective as that reported by Ludbrook and Brockwell (1952) in the 1949-50 season when the disease was not so serious. The fluctuation in disease rating indicates the necessity for adjustment of the spray programme to meet the particular requirements of each outbreak of the disease.

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GARDEN PEAS SUCCESSFULLY SOD-SEEDED

Summary

A satisfactory crop of garden peas was grown without seed bed preparation, in a paspalum pasture on a red basaltic soil near Lismore, N.S.W.

Introduction

In the course of pasture investigations on the red basaltic soils of the Richmond River district of N.S.W., Breakwell and Jenkins (1953) developed an overseeding implement for the purpose of sowing inoculated pasture legumes and fertilizer directly into dense paspalum (*Paspalum dilatatum*) pasture. This implement, now commonly known as a "sod-seeder', has been manufactured commercially and used extensively as a means of quickly establishing legumes in hillside pastures.

In 1952 it was found that the sod-seeder was also valuable for sowing leguminous fodder crops such as golden tares (*Vicia* sp.). Field peas (*Pisum arvense*), when similarly planted, failed due to lack of proper rhizobial inoculum treatment. An efficient strain for field peas was isolated by the Microbiology Section, and designated strain SU.300.

Figure 1.
Harvesting sod-seeded garden Peas at Wollongbar, near Lismore, N.S.W.

Experimental

During 1953 a simple field trial was conducted to determine the efficiency of rhizobial strain SU.300 in effectively nodulating garden peas sod-seeded into paspalum. A partially neutralised fertilizer was mixed with the seed before planting. Where the seed was inoculated with a heavy suspension of rhizobial strain SU.300 more than 95 per cent. of the plants became effectively nodulated, while without inoculum the mean effective nodulation was less than 10 per cent.

On April 29, 1955, an area of 0.4 acres of Massey Gem garden peas was sown into a closely grazed paspalum pasture, adjacent to the 1953 trial area, on the property of Mr. J. Corcoran, Wollongbar, near Lismore. The peas were planted in rows 28 inches apart by removing surplus tynes from the prototype sod-seeder. The fertilizer from three outlets was fed into each planting tyne. Unused fertilizer outlets were blocked.

Pea seed was inoculated with strain SU.300 at the rate of one 4 oz. agar bottle culture to 12 lb of seed, using a skim milk and calcium phosphate supplement. Seed and fertilizer were mixed immediately before sowing on a moist seed-bed. The seeding rate was approximately 60 lbs per acre.

The fertilizer used was mixed more than three months before and provided for dressings of molybdenised superphosphate and dolomite each at 192 lb per acre, plus sodium nitrate at 9 lb. per acre.

Results

The peas germinated satisfactorily and became effectively nodulated. Due to the mixing of the seed with the fertilizer, the spacing of the pea plants in the rows was not very even.

The first peas were picked eight weeks after planting and a total yield of 562 lb from 0.4 acres, or 1405 lb of green unshelled peas per acre was obtained. With the market price then at 2/9 per lb, this yield would represent a gross return of about £193 per acre.

Discussion

Although the yield from this experimental plot was not outstanding, it compares favourably with yields commonly obtained from prepared seed-bed plantings of this variety in the district.

The sod-seded crop has advantages in that erosion risk is eliminated and there is no costly seed-bed preparation or inter-row cultivation. Furthermore, the retention of the grass pasture permits full use of the paddock for grazing before the crop is planted and immediately after harvest.

It is realised that a garden pea crop can only be grown successfully under sod-seeding conditions when the grass pasture is dormant and the rainfall adequate.

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AN OUTBREAK OF PHALARIS STAGGERS IN SHEEP AT KOJONUP, WESTERN AUSTRALIA

At the C.S.I.R.O. Glen Lossie Field Station, Kojonup, Western Australia, 12 acres of *Phalaris tuberosa*, L., was stocked at 2 sheep per acre continuously over a 12 months period to study the persistence of phalaris and sheep performance. Twenty-five two-tooth Merino wethers were de-pastured on the phalaris from early December, 1952. The area carried a fairly heavy growth of phalaris together with a reasonable stand of subterranean clover (*Trifolium subterraneum*, L., Dwalganup strain) and the usual volunteer annuals viz., ripgut brome grass (*Bromus rigidus* Roth.), capeweed (*Cryptostemma calendula* (L) Druce), and Erodium (*Erodium botrys* (Cav.) Bertol.). All species had reached maturity and the sheep were on this dry feed for the first six months of the trial.

The opening rains for the 1953 season were 75 points recorded on May 16 followed by a further 65 points on May 23. By mid-June there was comparatively little growth of the annuals so that the sheep were feeding almost entirely on the young green leaves of *Phalaris tuberosa*.

On June 18 some of the sheep were observed to be excitable. During droving, two of the sheep collapsed and died within a few minutes. On examination of the remainder, eight were showing fairly definite symptoms of staggers while fifteen appeared normal. One of the more noticeably affected animals died on June 19. Most of the symptoms described by Lee and Kuchel (1953) were noted but the head nodding was not so apparent. Hyperexcitability was pronounced, especially if the animals were roused or hurried by dogs. In-co-ordination of gait was also apparent and the pounding heart-beat symptom was readily detected. Respiratory distress was particularly noticeable after a short run. All symptoms seemed to be more obvious on cold and wet mornings.

Liver samples were forwarded to Mr. A. B. Beck (C.S.I.R.O. Division of Animal Health and Production, Nedlands, W.A.). Four livers analysed showed a range of 150-228 ppm of copper and 0.12-0.15 ppm of cobalt on the dry weight basis. These figures were regarded as "normal". A composite sample of phalaris collected in June contained 5.9 ppm copper and 0.09 ppm cobalt: these values were classed as "low normal" or "marginal". The molybdenum content was 0.1 ppm.

Of the 25 sheep involved, only eight animals failed to develop any noticeable symptoms up to the time they were removed from the pasture at the end of 1953. Seven sheep developed marked symptoms but survived for some time after the initial symptoms were noted. The remaining ten animals deteriorated very rapidly and within a short time of noting the initial symptoms, either died or were killed when *in extremis*.

Cobalt Therapy

By July 1, four severely affected sheep were dead. On July 7, eight of the surviving sheep showing obvious symptoms of staggers were paired on clinical observations into two lots of four sheep each; in addition, the remaining thirteen sheep, which were showing no noticeable symptoms, were divided at random into two lots of six and seven sheep. Two groups,

of ten and eleven sheep respectively, were then formed as follows:—

	Group A	Group B
Showing initial symptoms	4	4
No initial symptoms	6	7
Total No. sheep	10	11

All sheep were then returned to the phalaris paddock from which they had been absent for two weeks.

Group A was drenched every second day with one fluid ounce of cobalt sulphate solution containing the equivalent of 9 mg. of cobalt. This drenching treatment continued until the end of October. Group B was not dosed but the sheep were running in the same pasture and subjected to the same yarding treatment every second day. All animals were examined at least twice each week for development of symptoms.

Results of observations are summarised in Table I.

It is fairly obvious that the cobalt therapy neither prevented the development of symptoms nor alleviated symptoms already present. Some of the apparently unaffected sheep developed symp-

TABLE I.

Trends of symptoms and variable course of staggers.

Group A (Dosed 9 mg. Cobalt thrice weekly)

Sheep No.	First Observed	Initial Symptoms	Course of Disease	Comments
B 972	18/6/53	V. severe	Uninterrupted	Killed in extremis 11/8/53
B 984	18/6/53	Severe	Uninterrupted	Killed in extremis 17/8/53
B 975	18/6/53	Very acute	Uninterrupted	Killed in extremis 10/8/53
B 965	18/6/53	Mild	Fluctuating	Died 13/9/53
B 983	9/7/53	V. mild	Fluctuating	Alive at 31/12/53
B 982	—	Nil	—	No symptoms 31/12/53
B 962	—	Nil	—	No symptoms 31/12/53
B 964	—	Nil	—	No symptoms 31/12/53
B 968	30/9/53	Severe	Uninterrupted	Killed 1/10/53
B 971	12/8/53	V. mild	Fluctuating	Killed 18/10/53

Group B (Control)

Sheep No.	First Observed	Initial Symptoms	Course of Disease	Comments
B 985	18/6/53	V. severe	Fluctuating	Died 23/10/53
B 969	18/6/53	Severe	Uninterrupted	Killed 29/7/53
B 961	18/6/53	Very acute	Fluctuating	Killed 14/10/53
B 966	18/6/53	Mild	Fluctuating	Died 25/9/53
B 967	—	Nil	—	No symptoms 31/12/53
B 979	—	Not observed	Not observed	Found dead 31/10/53
B 970	—	Nil	—	No symptoms 31/12/53
B 981	—	Nil	—	No symptoms 31/12/53
B 963	—	Nil	—	No symptoms 31/12/53
B 980	—	Nil	—	No symptoms 31/12/53
B 976	12/8/53	V. mild	Fluctuating	Alive on 31/12/53

Note: Of the four original sheep which were severely affected (see text) two died on June 18, when symptoms were first noted, one died the following day, and the other was killed for P.M. on July 1.

toms after the commencement of cobalt dosing, e.g., sheep No. B971 where the trend of the disease was described as fluctuating and also sheep No. B968 where no symptoms were noted until twelve weeks after the commencement of dosing followed by death within two days. These results differ in some respects to those obtained by Lee and Kuchel (1953) who found no incidence of staggers in ewes dosed with cobalt but they have also shown (private communication) that the condition cannot be alleviated if symptoms have been obvious for a week or more.

Effect of Topdressing Pastures with Cobalt

In 1954 portion of the phalaris pasture was sub-divided into two 4 acre plots. These have received annual topdressings with superphosphate (2 cwt/acre) and in addition one plot received cobalt (1 lb/acre cobalt sulphate) in 1954 only. No symptoms of staggers were recorded for any sheep on either plot in 1954.

In 1955 an unseasonal rain of six inches recorded in February resulted in a vigorous growth of phalaris with very little admixture of volunteer grasses. The two plots were stocked with 6½ sheep/acre for two months. Whilst conditions appeared favourable for the development of staggers no symptoms were recorded for any sheep on either plot during the two months, or for the remainder of the year when the stocking rate was decreased to 3 sheep/acre.

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COMPARISON OF MICROPROJECTION AND MICRONAIRE METHODS FOR DETERMINING MEAN FIBRE THICKNESS OF GREASY WOOL

A major problem in "Fleece Measurement" for the sheepbreeder is the provision of a rapid enough measurement of mean fibre thickness of greasy wool samples. In the first place, all greasy samples must be cleaned, as the yolk, which appears to adhere in clumps rather than in a uniform layer, affects the mean thickness. The normal microprojection method using "length-profiles" or cross sections is slow and the approximate method with cross sections (Hardy and Wolf 1939) though ingenious, does not appear to give the accuracy required. The Porous Plug Method (Cassie 1942) supplies an alternative approach, which gives promise of much greater speed in assessment. This has been manufactured in one form as the "Sheffield Micronaire." Unfavourable opinion unbacked by scientific analysis, has prevented the use of Micronaire methods, in Australian fleece measurement. It was deemed essential for this laboratory to investigate the degree of agreement between Micronaire and Micro-projection.

The Micronaire technique involves the forcing of a constant pressure of air through a standard weight of clean wool. The reduction in pressure due to the sample is recorded by a rotameter indicator, which is read directly in microns. The air pressure is calibrated by a manometer affixed to an alternate air route in the instrument. It is possible that some of the criticisms directed at the Micronaire re-

lated to an instrument without a manometer, as the method is very sensitive to change of air pressure. Experience has shown that a faulty reduction valve on the air-line, can retard the regaining of the test pressure long enough for an interference with the successive readings.

Comparative tests have been made on 190 different greasy wool samples, using both Micronaire and Microprojection according to their normal practice. In both cases degreased samples have been allowed to reach moisture equilibrium with an atmosphere of 67.5°F and 65% relative humidity, approaching it from the dry side. The Micronaire samples were weighed in, and the microprojection "length-profiles" were mounted in Euparal from this atmosphere. Duplicates were tested on the Micronaire, while two observers measuring 125 each, combined results when these agreed, to give 250 measurements on each microprojection test sample.

Results are given in Table I.

TABLE I.

Micronaire and microprojector measurement compared.

Set No.	No. of samples	A Micronaire Reading (microns)	B Micro-projector (microns)	B-A Mean Difference (microns)
1	10	23.1	23.0	0.7
2	28	22.4	22.1	0.8
3	33	23.9	24.3	0.9
4	30	20.2	19.8	0.8
5	27	23.7	24.3	1.0
6	32	21.2	22.0	1.0

While the means are reasonably close for groups, the next point of importance is the individual variation. In Table II, the distribution of difference (i.e., B-A) in each group are given.

In examining differences as reported in

TABLE II.

Summary of percentage distribution of difference (B-A) between micronaire and microprojection for groups listed in Table I.

Set No.	Mean Difference (B-A) in Microns				
	0—0.5	0.6—1.0	1.1—1.5	1.6—2.0	2.1—2.5
1	50	20	30	—	—
2	37	41	11	4	7
3	36	24	27	6	7
4	43	20	27	3	7
5	30	30	26	11	3
6	18	37	32	10	3
Means	35.7	28.7	25.5	5.6	4.5

Table II, the preparation of the test sample for Micronaire tests was discussed. Normally these have been hand-carded to give randomisation. Carding is a process whereby wire clothing mounted in a rubber backing is used to tease the fibres away from their neighbours and to assist in giving a thorough intermixing. Hand carding involves two brushlike units, whereas mechanical carding is a complex succession of carding and stripping motions. For small samples hand carding is feasible and the latter is not.

Three stages of preparation were obtained on the same stock, namely, "uncarded," "partially carded" and "thoroughly carded." From Table III it is obvious that the more randomised the fibrous material the more nearly do Micronaire and Microprojection measurements approach to one another.

TABLE III.

Comparison of uncarded, partially carded and thoroughly carded samples from the same stock, by micronaire and microprojection methods.

State	No. of Samples	A Micronaire	B Micro-projection	B-A Mean	B-A Maximum
Uncarded	10	21.6	22.9	1.3	3.0
Partially carded	10	22.0	22.9	1.0	2.1
Thoroughly carded	10	22.3	22.9	0.6	1.1

Conclusions

(1) Micronaire and Microprojection methods gave comparable group means with hand-carded samples.

(2) To ensure the closest agreement for individual means, it is concluded that the hand-carding should be thorough and the randomisation as complete as possible. Unless this is achieved, individual results may vary by as much as 2.4 microns.

(3) Thorough hand-carding adds to the time occupied in making the test, but the test can be carried out in the time involved in cleaning the sample; weighing 5.9 grams accurately; and pressing the sample into the test cylinder applying the air pressure, and recording the result by direct reading. It is estimated that each of these would occupy $2\frac{1}{2}$, 4 and 1 minute respectively, on a daily basis.

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(*Received for publication June* 7, 1956).

INFLUENCE OF MOISTURE ON EFFICIENCY OF BENZOL IN THE CONTROL OF BLUE MOULD OF TOBACCO

Summary

More benzol is required for prevention of blue mould in wet tobacco seedlings than in dry seedlings, a factor of considerable importance in seedbed management and in field control of the disease.

Introduction

It is now 20 years since Angell, Hill and Allan (1935) showed that infection by *Peronospora tabacina* Adam and development of blue mould of tobacco (*Nicotiana tabacum* L.) seedlings was prevented by benzol vapour. The required vapour concentration was obtained when the evaporation surface of benzol equalled 1/72 of the covered seedbed area. Subsequently, a lower ratio of evaporation surface was often used by growers with satisfactory results provided that conditions during the day were relatively unfavourable for infection and disease development.

Moist calico seedbed covers are essential for minimising loss of benzol vapour to the atmosphere. Moisture is also a solvent for the vapour. The fungicidal effect of vapour concentration in the aqueous layer on leaves was considered sufficient reason for expecting better disease control with wet than with dry plants (Wolf *et al* 1939). However, rates of benzol application commonly used by growers are sometimes inadequate, plants become infected, and the consequent transfer of such apparently healthy seedlings to the field is of major significance in the development of epiphytotics.

In our experiments, observations were made on the effectiveness of benzol in preventing blue mould in seedlings kept either wet or dry during the day.

Methods

Disease-free tobacco seedlings grown in 4 inch pots, using 16 replicates, or in flats measuring 60 x 30 cm. were placed in iron trays measuring 71 x 71 x 23 cm. and provided with removable glass covers padded to prevent undue loss of benzol vapour. The evaporation surface of benzol was 1/200 of the area of the tray and the depth of the container was 0.8 cm. The quantity of benzol applied each evening varied according to treatment from none to 5 ml. All benzol had vapourised before the removal of covers each morning, at which time there was only a slight smell of the vapour. Also at this time all leaves were covered with droplets of water which subsequently disappeared in about one hour from plants of the dry treatments.

The two broad groupings of treatments were into seedlings wetted during the day and hereinafter referred to as wet plants, and seedlings not wetted, which are referred to as dry plants. In some trays peat moss, kept saturated with water, was packed around the pots or flats. Thus the 8 treatments were wet plants and dry plants both with and without wet peat moss, and with and without benzol.

All seedlings used in the experiments were inoculated with a suspension of conidia during the late afternoon on the day before benzol was used and again on the following morning. Additionally a continuing source of inoculum was provided by numerous diseased plants in the same glasshouse. Occurrence and severity of disease were used as a measure of treatment effects.

Experimental

In the first experiment, benzol at the rate of 5 ml., later reduced to 4 ml., each night prevented disease. When the quantity of benzol was reduced to 3 ml. per

night, and the same plants again inoculated, isolated small chlorotic spots appeared on wet plants in wet surroundings after 6-7 days and a few days later on wet plants in dry surroundings. Fructification occurred on these spots if the leaves were removed and kept under moist conditions for several days. More severe symptoms developed when benzol was subsequently reduced to 1 ml. for 7 days but fructification was not apparent until three days after treatment with benzol was discontinued, by which time it was general throughout.

Where benzol was not used, fructification occurred on wet plants 5 days after inoculation, in other treatments after 2 more days, and all plants were dead within 19 days. Temperature in the trays during this experiment varied from minimums of 46-60°F. to maximums of 60-80°F. All replicates behaved similarly and in all subsequent experiments, in which flats were used, there was a uniform distribution of affected plants.

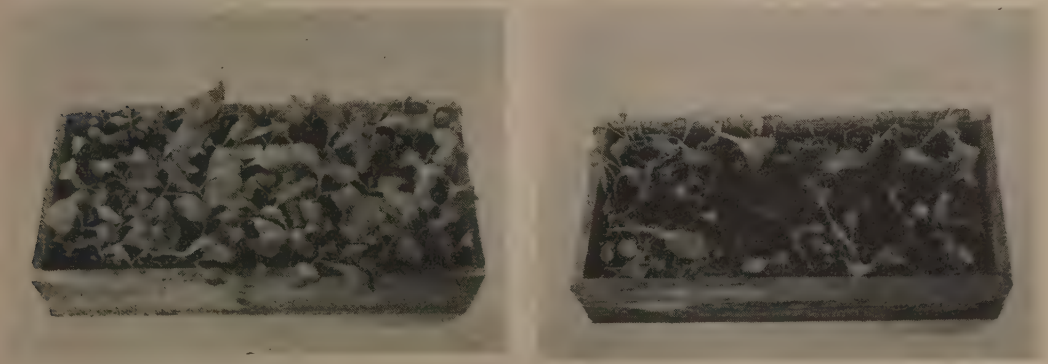
In another experiment in which 1 ml. of benzol was used each night, the disease appeared in all treatments 5 days after inoculation, the most severly affected plants being those without benzol and wetted during the day. When benzol was increased from 1 to 3 ml., fructification was prevented and intensification of other symptoms of the disease occurred only in the wet plants. This was evident in enlargement of disease lesions, leaf distortion and stem necrosis. Where benzol was not used wet plants collapsed 7 days before dry plants.

These two experiments showed that the disease occurred earlier and was more severe on wet plants than on dry plants and that the minimum quantity of benzol needed to prevent development of disease in plants kept dry during the day did not prevent development of the disease in wet plants.

Similar trends were apparent in two other experiments in which benzol was used at the rate of 2 ml. each night. In the absence of benzol, fructification occurred on wet plants 6 days after inoculation, and on dry plants several days later. All died within 17 days, Figures 1 (a) and 1 (b). Where benzol was used, sparse fructification was evident on chlorotic areas on wet plants 10 days after inoculation. The condition of the seedlings at the conclusion of the two experiments is shown in Table I, and in Figures 2 (a) and 2 (b). Temperature ranges were, minimum 52-66°F. and maximum 75-90°F.

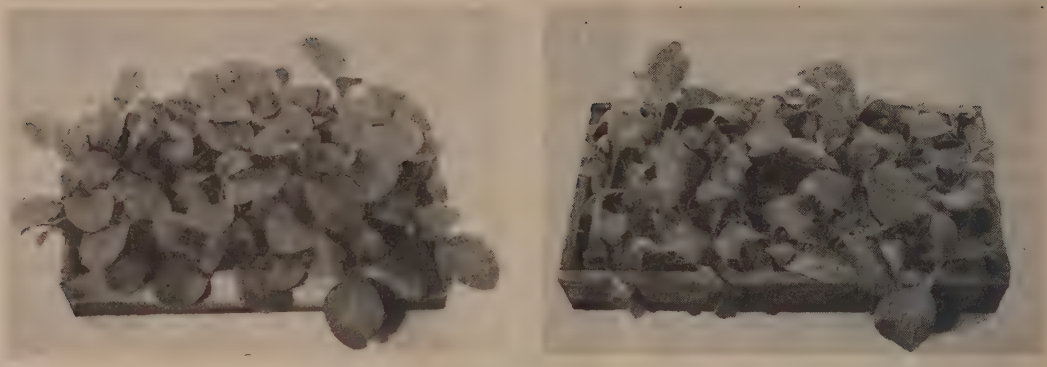
Discussion

Results in all four experiments were consistent in that blue mould became ap-



(a) (b)

Figure 1.
Tobacco seedlings not protected by benzol photographed 14 days after inoculation with conidia of P. tabacina.
(a) Plants dry. (b) Plants wet.



(a) (b)

Figure 2.
Tobacco seedlings with insufficient benzol, photographed 24 days after inoculation with conidia of P. tabacina.
(a) Plants dry. (b) Plants wet.

parent on wet plants before it appeared on dry plants. Additionally the disease was slightly less severe on plants in dry than in wet surroundings. In the absence of benzol such differences would not be of significance in disease control. Although all seedlings were wet at the time of removal of covers in the morning, the droplets on dry plants were small and usually disappeared in less than an hour. With wet plants, conditions were favourable for infection by airborne conidia during the day as would occur in the field especially on cloudy, wet days.

The role of water in blue mould control was investigated by Wolf *et al* (1940) in studies of the mode of action of benzol as a volatile fungicide. They found that moisture acts as a fumigant storage, and concluded that, for benzol vapour to be an effective fungicide there must be sufficient present in aqueous solution to ensure lethal concentration on the leaf surface. From our results it is clear that if the quantity of benzol vapour is low relative to water available for its absorption, the disease will not be prevented, but its rate of development may be retarded.

TABLE I.

*Occurrence of blue mould on wet and dry seedlings when Benzol was used each night**

Treatment		Disease rating†					Comment
Plants	Surroundings	1	2	3	4	Total	
Wet	Wet	—	26	20	76	122	Fructification sparse on severely affected plants.
Wet	Dry	—	47	39	47	133	„ „
Dry	Wet	—	96	26	12	134	No fructification
Dry	Dry	56	37	20	10	123	„ „

* In the same treatments but without benzol, all seedlings were dead 7 days before conclusion of the experiments

† 1. apparently healthy.
2. scattered small chlorotic spots.
3. scattered large chlorotic areas and some leaf distortion.
4. stem necrosis, leaf distortion and dead areas; fructification in some treatments.

In some treatments in the present experiments centre of infection that developed slowly were apparent as chlorotic spots which did not fructify until the leaves were removed and held under humid conditions for 3-4 days. In commercial practice such plants, and others in which the disease is progressing towards the chlorotic spot stage, occur in seedbeds when benzol vapour concentration is low. After transplanting such spots are centre of infection for spread of blue mould in the field. By increasing the concentration of benzol vapour, mycelium in the leaves is killed (Hill and Angell 1936) and provided the stem is not affected, the seedlings make satisfactory transplants.

Wolf *et al* (1939) state that control by benzol vapour is more effective with wet than with dry plants provided "effective fungicidal concentration of benzol vapour in water could be expected to exist throughout the entire night." Our results show that the efficiency of benzol as a volatile fungicide is reduced by water on the leaves and by wet conditions within the seedbed and that more benzol is required for prevention of blue mould in seedbeds during periods of wet weather or when the plants remain wet for long periods than when plants are dry during the day.

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(*Received for publication, January* 31, 1956).

LETTER TO THE EDITOR

Moisture Content Values for Botanical Material

Sir,

It is proverbial that figures can often be made to lie. Those commonly given to indicate moisture content changes during such processes as haymaking, if not actually false, may still be very misleading. For example, the moisture content at the time of mowing is given as perhaps 80 per cent.; this indicates that, at this stage, the plants consist of 80 parts water and 20 parts dry matter. Similarly, the moisture content may be given as 40 per cent. at the time of raking; this indicates that the plants now consist of 40 parts water and 60 parts dry matter.

At first glance one is quite likely to assume that, as the moisture content has dropped from 80% to 40%, half the moisture has been lost. In actual fact, the loss is much greater than this as will be seen from the following considerations:—

Take 100 parts of dry matter; there are then 400 parts of moisture associated with this at the time of mowing but only $66\frac{2}{3}$ parts at the time of raking. In other words, the plant has lost $\frac{333\frac{1}{3}}{400}$ or $83\frac{1}{3}\%$ of its moisture and not just 50% as might well be thought.

Why not express moisture contents as percentages of the weight of dry matter which is reasonably constant, rather than on the constantly varying wet weight? Admittedly there are difficulties in obtaining an absolutely precise value for the dry matter content of botanical material but these are experienced whether the dry weight or the wet weight basis is used. For practical purposes a reasonably accurate dry weight can be obtained by oven drying and, in fact, this method is usually employed in determining moisture contents.

When the dry matter basis is used the whole picture of moisture content changes becomes mathematically clear; 80% moisture (wet weight basis) becomes 400% (dry weight basis), 40% becomes $66\frac{2}{3}\%$ and the loss in moisture ($400-66\frac{2}{3}\%$) or $333\frac{1}{3}\%$ (dry weight basis). The $333\frac{1}{3}\%$ is a true figure and can be used in statistical analyses whereas the arithmetical difference between 80% and 40%, the values on a wet weight basis, is completely false as an indication of the change that has occurred.

The dry matter basis for expressing moisture contents is far more logical than the "wet" or "time of test" basis; it was adopted many years ago by those working on timber. Is it asking too much for those working with other forms of botanical material to follow suit?

W. L. GREENHILL.

Officer-in-Charge,
Plant Fibre Section,
C.S.I.R.O.,
Highett, Vic.

June, 1956.

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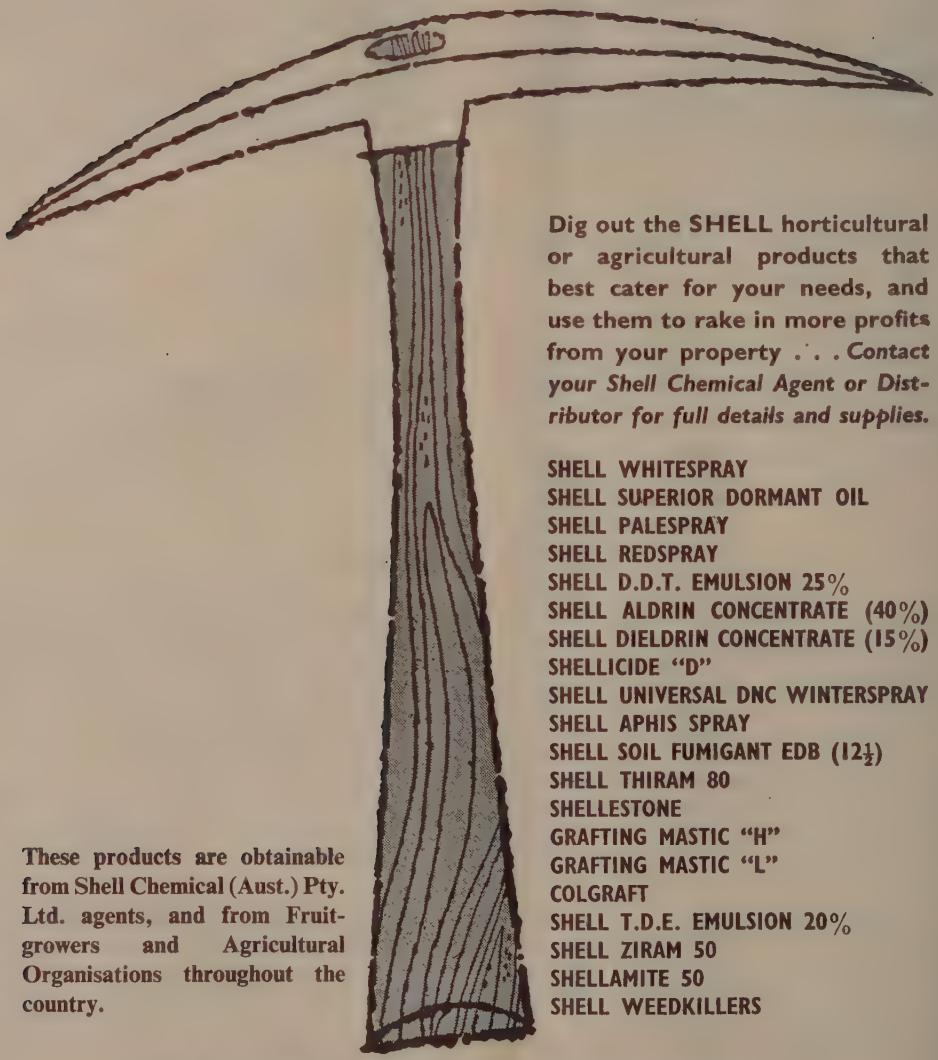

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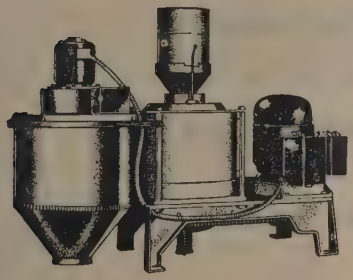

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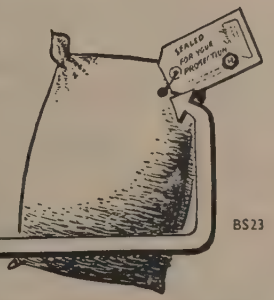

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NEWS ITEMS

Degree Course in Agricultural Engineering

The Council of the University of Melbourne in March, 1956, established an undergraduate degree course in Agricultural Engineering. This makes the eighth degree course in the Faculty of Engineering, the others being in Civil, Electrical, Mechanical, Mining, Metallurgical, Chemical Engineering, and Surveying. Like these other courses, the new course will be of four years duration; it will lead to the degree of Bachelor of Agricultural Engineering.

To the members of this Institute a special point of interest is the fact that this is an engineering course, within the Faculty of Engineering. Broadly speaking, the curriculum is a basic course in civil and mechanical engineering with applications in the field of agriculture, virtually at farm level. Such a course will require and will have as a background an introductory course in Agricultural Science.

The first two years of the course will, as usual, consist of basic science and mathematics and an introduction to applied science in engineering. These two years are in fact the same as for the course in civil engineering.

The third year contains the introduction to agricultural science, most of the subject known as Agriculture Part II taken in third year agriculture. Third year also includes the new subject "Earth Science," specially designed for the civil and agricultural engineering courses; this subject combines in roughly three equal parts, geology, soil chemistry, and soil physics and mechanics. Engineering design, and courses in heat, electricity, and fluid mechanics complete the third year.

Fourth year consists of Machine Design (as taken in final year mechanical engineering) and three subjects listed—for want of better titles —as Agricultural Engineering A, B and C.

A—means Power and Machinery, including electrical applications.

B—means Farm Buildings and Structures.

C—means Soil and Water Engineering: hydrology, water supply, irrigation, drainage, soil erosion.

Obviously this is a course in engineering, not in agriculture or agricultural science, and is a far cry from the course in elementary engineering taken by the fourth year students of Agricultural Science at this and other Universities. The course may be taken by any student who has Matriculated for entry to the Faculty of Engineering.

Though the graduates in Agricultural Engineering will very likely find employment in many of the fields usually open to Civil and Mechanical graduates, they will be particularly suited for the agricultural machinery and tractor industries, for the service departments of water, irrigation and soil conservation, for investigation and extension in the departments of agriculture, and in the Agricultural Colleges.

In creating the first such degree course in Australia and one of the few in Commonwealth countries, the University of Melbourne has responded to a lively interest in this subject and to the need for its development in Australian Agriculture. So too have the several companies who have agreed to subscribe the extra funds required by the University to provide the course, namely:

H. V. McKay Massey Harris.
H. V. McKay Charitable Trust.
Harry Ferguson of Australia and British Farm Equipment.
International Harvester Company of Australia.
The Ford Motor Company of Australia.
Caterpillar of Australia.
Mobile Industrial Equipment Limited.
Imperial Chemical Industries of Australia and New Zealand.

The third year of the course began in first term 1956, a week after the course was announced. Three students, who had passed the first two years in Civil or Mechanical Engineering, chose on very short notice to change to the new course. Larger numbers are expected in future years.

Cereal Scientist Honoured

World Award to Professor W. L. Waterhouse

First recipient of THE ELVIN CHARLES STAKMAN AWARD is Emeritus Professor Walter Lawry Waterhouse C.M.G., M.C., D.Sc.Agr., D.I.C., H.D.A., F.L.S., who retired from the University of Sydney Faculty of Agriculture in 1952.

Details have been received from the Stakman Endowment Fund Committee in the University of Minnesota, U.S.A., by Australian Regional Representative of the Committee, Dr. R. J. Noble, N.S.W. Department of Agriculture.

The Stakman Award may be made to an individual in any country for outstanding research in cereal pathology, and comprises a Medal, a Scroll, and a nominal monetary grant.

Former students and associates of E. C. Stakman, Emeritus Professor of the University of Minnesota, U.S.A. endowed the Fund to commemorate Professor Stakman's "contributions and life long dedication to scholarly leadership in biology, agriculture, education and the humanities."

Nominations invited from Regional headquarters in Australia, Canada, Egypt, England, India, Japan, Mexico, Pakistan and South America were considered for the Award by the Stakman Fund Committee in U.S.A.

Professor W. L. Waterhouse received the Award for "his research in cereal pathology, his studies of the cereal rusts and their hosts, his breeding of rust resistant wheats, and his teachings which have inspired so many of his students to continue the research in those fields."

Walter Lawry Waterhouse graduated B.Sc.Agr. from the University of Sydney in 1914 with First Class Honours and the University Medal. He was the first Farrer Memorial Scholar, and in 1915 was awarded the 1851 Exhibition from which he resigned for War Service.

In World War I he served in Egypt and France and was awarded the Military Cross.

As Walter & Eliza Hall Fellow from 1918 to 1920 he studied at the Imperial College of Science and other institutions in England, and later in the U.S.A.

In 1929, for his thesis derived from world acclaimed research into the cereal rust fungi, he became the first graduate to receive the University of Sydney Doctorate degree in Agricultural Science.

From 1921, Professor Waterhouse lectured and demonstrated in Plant Pathology, Genetics and Plant Breeding, and Agricultural Botany at the University of Sydney, whilst pursuing research in cereal pathology and wheat breeding.

A Research Professorship was conferred on Dr. Waterhouse in 1946, and between 1946 and his retirement in 1952 he twice acted as Dean of the Faculty of Agriculture whilst continuing his research.

Pig Progeny-Testing Station at Werribee, Victoria

The first pig progeny-testing station in Australia has been established at the Animal Husbandry Research Centre at Werribee, Victoria. The Victorian Department of Agriculture has been developing the techniques and facilities for testing at Werribee for the past two years and is now ready to accept the pure-bred progeny of any breed for testing up to baconer weights.

As boars influence a breeding programme more than sows, emphasis will be placed on testing three litters sired by one boar.

The progeny will be evaluated by recording their age at slaughter, the feed eaten, the carcass weight and appraisal of carcasses.

Subsequent progeny sired by boars which have performed well in the tests will be of great value to the pig industry in its efforts to improve efficiency of production.

The establishment of this pig testing station is a direct result of requests from stud breeders for such a service.

Hazeldean—The First Victorian Linseed

The Victorian Department of Agriculture has developed a new variety of linseed named Hazeldean.

The new variety represents the first result of a breeding programme undertaken by the Department with the object of stabilizing the linseed industry in Victoria. It is expected that the introduction of Hazeldean will do much to eliminate losses in yield due to the ravages of the two major diseases affecting this plant—rust and wilt.

Hazeldean is immune to all Australian races of linum rust and, in addition, is highly-resistant to wilt. In general growth characteristics, in maturity and oil content, it resembles the present standard commercial variety—Walsh. It is superior to Walsh, however, in yield and in its capacity to resist disease. In nine yield trials in the Western District over the past five years Hazeldean outyielded Walsh by 33 per cent.

The average yields per acre of Hazeldean and Walsh have been 19.5 and 14.7 bushels, respectively.

Hazeldean was developed as the result of a co-operative effort involving plant breeders, pathologists and agronomists of the Department of Agriculture, and growers on whose properties much of the selection and testing work was carried out.

From the progeny of a wilt-resistant plant isolated by the Senior Pathologist, Dr. C. R. Millikan, the Cereal Geneticist, Mr. P. H. Debrett, selected plants combining resistance to rust, desirable agronomic characters and high-yielding ability.

Selections for rust resistance were made at the State Research Farm, Werribee, while selections for character and type were made from plots located on the property of Mr. H. Currington at Warncoort, Victoria.

Man and Animals in the Tropics

The Australian Academy of Science conducted a Symposium at the University of Queensland on the 24th and 25th May, 1956. The theme of the symposium was "the impact of the physical and biological environment on man and his domestic animals in the Australasian tropics", and the purpose "to review the present position of research, and assess the more urgent needs for future development".

University of Queensland Field Day

Mr. P. J. Skerman, Senior Lecturer in Agriculture, University of Queensland, organized a field day at Gowrie (Charleville) in association with *Mr. W. R. Horne,* also of the University staff. Mr. Skerman outlined the aims of the University's experimental programme on Gowrie, namely, drought mitigation by conservation of crops grown on the heavy soils and the greater carrying capacity by introduction of improved pastures with better utilization of frontage and mulga country. This was the fifth Field Day held by the University in the far western sheep areas of the State during the past two years, the others being at Richmond, Muttaburra, Blackall and previously also at Charleville. Grazier interest has been high.

Tobacco Research in Queensland

The Department of Agriculture and Stock, following the agreement between Commonwealth and State Governments on the operations of the Tobacco Industry Trust Fund Account will be responsible for the expenditure of £42,000 on capital works in connection with tobacco research and extension in Queensland. A large portion of this sum will be used to accelerate the work already commenced at Inglewood and Parada Tobacco Experiment Stations. The C.S.I.R.O. will also be spending in Queensland a large proportion of the £72,000 allotted to it for capital

expenditure in connection with tobacco investigations. Most of this money will be contributed equally by the tobacco manufacturers and the Commonwealth Government. Maintenance of these establishments will require approximately £50,000 annually which will be raised by a tax on leaf sold by growers and domestic leaf purchased by manufacturers, together with a substantial contribution by the Commonwealth Government.

Provision of special expenditure for undergraduate scholarships and overseas visit by an Agronomist from the Department of Agriculture and Stock has also been made. Three scholarships were made available under the normal Public Service conditions and two of these have been allotted. A fourth scholarship which was sponsored by the South Queensland Tobacco Growers' Association should be filled after the results of this year's Senior Public Examination are published.

Australian Veterinary Conference

One hundred delegates from all States were in Brisbane for the Australian Veterinary Association's annual conference from 28th May to 1st June, 1956. At the conference, *Dr. J. Legg*, Director of Animal Research, Animal Research Institute, Yeerongpilly, was awarded the Gilruth prize. This prize was established to commemorate the name of the late *Dr. J. A. Gilruth*, a Dean of the Faculty of Veterinary Science, University of Melbourne.

Agriculture in the Central Highlands of Queensland

Within a few years, 100,000 acres of land in the Central Highlands are expected to be under cultivation. Already upwards of 50,000 acres are producing summer and winter grain crops. In addition to the green crops, sudan grass and oats are grown for grazing, successful crops of cowpeas and sweet sorghum for silage are produced and canary seed is being sown this winter. Cropping combined with sheep and cattle promises to be the form of land utilisation best suited to the area.

Buffel grass is showing distinct promise of becoming an important pasture species in this region and there are indications that green panic may also be suitable. The legumes, phasey bean and lucerne, are used in combination with these grasses. In an experimental block near Emerald, the Gayndah strain of buffel grass seems to be suitable for grazing by sheep while type D and a closely allied strain should provide satisfactory grazing for beef cattle.

It is clear, however, that the establishment of a permanent agriculture in the Central Highlands will require the application of soil conservation measures. In this, the use of pastures in the cropping rotation will play an important part. Pastures will not only help check soil erosion but will also assist in maintaining the productivity of the soil.

Rice in New Guinea

With applications of phosphate, and protection against insects, kangaroos and other marsupials, successful crops of rice have been grown in Netherlands New Guinea near Merauke. This is part of the Koembe project which aims at large scale mechanical cultivation of rice. The final object is 30,000 acres, in combination with a cattle raising industry.

Mobile Extension Unit, Victorian Department of Agriculture.

In February 1954 the Victorian Department of Agriculture established a Mobile Extension Unit as a project under the Commonwealth Extension Services grant. The aim was to enable farmers to attend lectures and demonstrations within their own district and to hear from specialists in each subject ways and means of applying research findings which would be of benefit to farming practice.

With a general shortage of extension officers, the mobile unit is proving to be an effective means of imparting information to as many farmers as possible. Since its inception the unit has visited many centres throughout the state and has attracted some 56,000 visitors to the various sessions.

An outstanding feature has been the co-operation achieved with other departments concerned with the primary industries as well as various farmer organisations and private farmers themselves. Speakers from the Forestry Commission, Department of Lands and Survey, State Rivers & Water Supply Commission and the State Electricity Commission have joined with Department of Agriculture speakers to enable a wide coverage of subjects. In addition facilities have frequently been supplied by these organisations, and also by graziers, to enable effective demonstrations to be staged.

The Country Women's Association provides active co-operation in the staging of demonstrations of home cooking and other subjects of interest to the farmer's wife.

The unit spends three days at each centre with morning, afternoon and evening sessions each day. Films are shown wherever possible and emphasis is placed on audience participation through questions and general discussion.

The itinerary of each tour is decided by an Extension Services Advisory Committee which consists of a representative from each of a number of rural associations together with senior officers of the Department of Agriculture.

Local committees at each centre are responsible for catering, publicity and selection of the site for the two marquees, one of which houses exhibits and the other being used for lectures. The local committee also recommends subjects for discussion and these recommendations are considered by an inter-divisional committee of the Department which arranges a programme to suit the availability of speakers.

Agriculture Victory at Melbourne.

Agriculture took the 1956 Faculty Football (Aust. Rules) Premiership from Commerce by 10-7 to 8-10.

This is the first time in the history of Melbourne Faculty Football that Agriculture have been Premiers. Agriculture is, by the way, the smallest Faculty in the competition.

Extensions to School of Agriculture, Melbourne

Opening of Extensions to the School of Agriculture, University of Melbourne.

On 28th June the Minister for Education, Mr. Bloomfield, opened the new extension to the School of Agriculture at the University of Melbourne. These extensions have been demanded by the growing student numbers and the expanding activities of the Agriculture Faculty.

The extension was built at a cost of approximately £30,000 and was greatly assisted by a most generous gift of £11,000 from Mr. and Mrs. V. Y. Kimpton. It has two lecture theatres, the largest to be called the Kimpton Lecture Theatre; one large laboratory, convenient administrative rooms and three new research rooms.

The older part of the building is being re-equipped as finance becomes available, to cater for research teams. Previously, lack of space tended to restrict the scope of the School's activities, but with the added space and better facilities, re-organisation of research and instruction will be possible. Sections of the building will be used by research workers in animal husbandry, soil chemistry, agricultural botany, agricultural engineering and rural economics.

The table below shows the growth of student numbers in recent years. This no doubt reflects the growing realisation by the public in general of the place of science in agricultural affairs.

Year of course	1951	1952	1953	1954	1955	1956
1	24	37	48	61	51	71
2	24	16	18	26	33	30
3	30	36	21	26	37	54
4	28	16	27	18	17	19
Graduates	26	18	22	18	17	—

The number graduating at 5 year intervals from 1935 to 1950 are: 1935, 16; 1940, 10; 1945, 9; and 1950, 34. The high 1950 and 1951 numbers are due to the influx of exservicemen.

Professor Sir Samuel Wadham is to be complimented for the work involved in negotiating for and designing these extensions, and for his recognition of the need for combined research and teaching to stimulate the training of students. He has led and developed the Faculty for the past 30 years and these extensions represent a final achievement before he retires at the end of this year. He has furnished a sound base on which his successor can maintain a first class school.

Seventh International Grasslands Congress.

The Seventh International Grasslands Congress will be held at Massey Agricultural College, New Zealand, from 6th-15th November, this year.

The aim of the Congress is to bring together as many as possible of the world's leaders in grassland work and to give them an opportunity to exchange information and ideas on grassland production and problems.

The Congress is being sponsored by the New Zealand Government under the auspices of the New Zealand Grassland Association which has set up an organizing committee to make the necessary arrangements.

Papers presented at the Conference will be at a specialist level and will be given by persons actively engaged in aspects of grassland research.

Two post-congress tours have been arranged so that visitors will have the opportunity to see as much as possible of agriculture in either the North or South Island.

Irrigation Research in N.S.W.

In conjunction with the Water Conservation and Irrigation Commission the N.S.W. Department of Agriculture is establishing an Irrigation Research Centre at the Department's Yanco Experiment Farm in the Murrumbidgee Irrigation Area. It will be administered by a committee under the chairmanship of Mr. Bowmaker of the Department of Agriculture.

Mr. D. J. Guyatt, who will later be stationed at the centre, is undertaking a special course of training in hydrology and fluid mechanics at the N.S.W. University of Technology.

N.S.W. Wheat Sowings.

Following the prolonged rains earlier in the year much of N.S.W. wheatlands have been so waterlogged and weed-infested that wheat sowings this season were only about 50 per cent. of normal. Sowing was also greatly delayed. Weeds

are still a serious problem in the planted areas, mainly ryegrass and skeleton weed in the south and thistles and black oats in the north. Crop prospects are very poor.

Apple and Pear Growers Conference.

The annual Conference of the Australian Apple and Pear Growers' Association was held at Bathurst, N.S.W., on 8-9th August and was attended by delegates from all States and by representatives of State Departments of Agriculture and the Commonwealth Department of Primary Industry. The Conference was officially opened by the President of the Rural Bank of N.S.W., Mr. C. R. McKerihan. Mr. McKerihan paid a tribute to the work of the C.S.I.R.O. in increasing Australia's primary production and expressed an optimistic view of Australia's economic future He considered that the current economic pessimism was not justified by the facts. The Conference discussed export problems, publicity in overseas and local markets, the problem of the sharply rising costs of spray materials, the problem of toxic spray residues on apples and pears and interstate transport. It was felt that problems of excessive spray residues on fruit and their removal should be actively investigated by C.S.I.R.O.

In his report, the retiring President, Mr. H. K. Caldicott reviewed the past export season in which a total of 4½ million bushels of apples and 1 million bushels of pears were exported, mainly to the United Kingdom but increased quantities were sold on German, Swedish and Belgian markets. Exports prices were satisfactory but home market prices were lower than they should have been. Increasing costs of production and marketing have become a major problem for the industry.

The Conference was addressed by Mr. J. B. Mills, Chairman of the Australian Apple & Pear Board who reviewed export marketing problems. Addresses were given by Dr. F. T. Bowman and Mr. K. Hutton of the N.S.W. Department of Agriculture respectively on the subjects of "Hormone Sprays" and "Control of Black Spot by Eradicant Sprays." Mr. E. G. Hall of C.S.I.R.O. spoke on "Superficial Scald of Apples in Storage" and Mr. N. D. Honan of the Bureau of Agricultural Economics spoke on "Trends in Fruit Consumption."

Land Contest.

The "Daily Advertiser" at Wagga, N.S.W., conducted a land contest during July and August for boys and girls under 17 years of age. The object was to promote an interest in agriculture and contestants were required to answer a series of questions, including photo-quizzes. Prizes for boys included a scholarship tenable at Wagga Agricultural College. This contest attracted a great deal of attention and the newspaper is to be congratulated for its novel and successful promotion of an interest in agriculture and careers in agricultural science amongst young people.

Australian Society of Soil Science.

The Australian Society of Soil Science was recently formed with the objects of advancing soil science, with particular reference to Australia and providing a link between soil scientists and members of kindred bodies within Australia and in other countries. Membership is open to all persons engaged in the scientific study of the soil. The organization and articles of association of the society are similar to those of the A.I.A.S. and it is a body which our Institute should support. The N.S.W. Branch of the Society of Soil Science was formally constituted in July last with a membership of 20. Co-operation between the Institute and the Society is very desirable and will be of considerable mutual benefit.

Increased demand for Rye.

There is a rapidly rising demand for locally grown cereal rye grain, due in large measure to the influx of migrants from Europe. One firm alone in Sydney now requires very much more than the small N.S.W. production and its requirements for 1957 are approximately 150,000 bushels. There is consequently a greatly increased interest in the growing of rye for grain.

Enrolments in Agricultural Science Courses—1956.

University	Year of Course					No's. Completed Course—1955	
	1	2	3	4	Hons.	4th	Hons.
Adelaide	41	17	7	10	2	4	1
Melbourne	71	30	54	19	—	17	—
Queensland	29	16	14	3	8	9	2
Sydney	98	49	34	24	3	19	6
Tasmania	2	—	—	—	—		
Western Australia	22	11	7	12	3		
Totals	263	123	116	68	16	49	9
Associated Courses:							
Wool Technology (Sydney)	6	3	4	6	—	3	—
Rural Science (New England)	17	—	—	—	—		
Agricultural Engineering (Melbourne)	—	—	3	—	—		

Enrolments 1951-55 — see Journal of Australian Institute of Agricultural Science, September, 1955, p. 194.

However, Mr. C. Walkden Brown, cereal specialist in the N.S.W. Department of Agriculture has pointed out that yields of rye grain on comparable land are appreciably lower than those of wheat or oats and growers would need to receive a much higher price per bushel to make growing rye for grain an attractive proposition.

Farrer Memorial Medal.

Mr. A. F. Bell, B.Sc., M.S.(Agr.), D.I.C., A.A.C.I., Under Secretary of the Queensland Department of Agriculture and Stock has been awarded the 1956 Farrer Memorial Medal. Mr. Bell is a Past President of the Australian Institute of Agricultural Science and received the medal awarded by the Institute in 1954. The Farrer Medal is awarded annually by the Farrer Memorial Trust in N.S.W. to commemorate the work of Australia's pioneer wheat breeder and to honour one who has rendered distinguished service to agricultural science in Australia.

Mr. Bell delivered the Farrer Memorial Oration at the 32nd Annual State Congress of the Agricultural Bureaux of N.S.W. at the Hawkesbury Agricultural College last July. He said that, with Australia's vulnerable economy, in which so much had to be exported to pay for the large essential imports, Australia's primary industry needed the maximum assistance from scientific services to ensure a high degree of efficiency to enable it to compete on world markets. The standards of agricultural training must progressively rise and much more attention must be paid to post-graduate training.

New Fruit Fly Laboratory.

Extensions to the joint C.S.I.R.O. and N.S.W. Department of Agriculture's Citrus Wastage Research Laboratory at Gosford, N.S.W., to house intensified investigations into post-harvest disinfestation treatments of fruit, especially citrus, against the Queensland fruit fly were officially opened on 2nd August by Dr. H. J. Hynes, Assistant Director, N.S.W. Department of Agriculture. Dr. Hynes stressed the importance of this work to the citrus industry, both in respect of export and interstate trade and also spoke of the various activities of the Department of Agriculture in the Central Coast area. The investigations being undertaken will form the main part of a co-operative programme between C.S.I.R.O. and State Departments of Agriculture in N.S.W., Victoria and South Australia and the whole programme is being financed jointly by Governments and the Federal Citrus Council.

The principal activities in the new laboratory will be the breeding of large numbers of flies in a special air-conditioned insectary, which are essential for artificial infestation of the large numbers of infested fruits required and a close study of the fumigation treatment with ethylene dibromide which should be of greater practical value than the previously developed low temperature treatment of the fruit. Mr. S. E. Keenan, President of the Federal Citrus Council of Australia paid a tribute to the work being done and stressed the importance of the fruit fly problem which is a very serious threat to the fruit industry in Australia.

South African Exports threaten our Fruit Trade.

South Africa is rapidly becoming Australia's chief competitor on English and European markets for imported apples and pears. In the last five years apple exports from South Africa have greatly increased and the immediate production potential of apples and pears in that country, which already exports large quantities of citrus, grapes and soft fruits, is very great. Production and marketing costs are so much lower in South Africa than in Australia that it is clear that our fresh fruit export industry is facing a very difficult period of highly competitive marketing overseas. Competition on the English market from other countries such as U.S.A., South America, and even European countries, is steadily increasing.

Visiting Scientists.

Dr. Maurice Schmid, a French Agriculturalist, visited a number of C.S.I.R.O. establishments early in the year while on his way to Indo-China.

Dr. J. D. Atkinson, Director of the Fruit Research Station, D.S.I.R., New Zealand, recently visited Canberra.

Prof. D. F. Cavalcanti of Brazil visited Australia on a United Nations Fellowship and spent some time visiting places of interest in Queensland.

Dr. J. G. Horsfall, Director of the Connecticut Agricultural Experimental Station, New Haven, U.S.A., recently visited Canberra.

Dr. Horsfall is the foremost expert in U.S.A. on the testing of efficiency of new fungicides and insecticides.

Prof. J. Bonner, Professor of Botany at the California Institute of Technology, is at present spending three months with the C.S.I.R.O. Biochemistry group at Canberra. Prof. Bonner has already visited several states where he has addressed Institute meetings.

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TALKS

War Service Land Settlement in Tasmania

R. A. Paul, Acting Deputy-Director of War Service Land Settlement for Tasmania.

The Tasmanian Government is an agent for the Commonwealth in war-service Land Settlement and the actual development is carried out by the Land Settlement Division of the Agricultural Bank. After development the Agricultural Department supervises the schemes.

When a block has reached the stage where it will carry twenty-five milking cows or five hundred breeding ewes it is allotted to a settler who pays a low rental and agistment charge but development continues till the capacity reaches thirty-five to thirty-seven cows or six hundred ewes.

Charges made to the settler for stock, plant and structures are approximately as follows:—

Stock £2,000—3¾% repayable over ten years.
Plant £2,000—3¾% repayable over ten years.
Structures £2,750—3¾% repayable over thirty years.

The settler's commitment is therefore apparently £850 out of an income of approximately £2,600. The rental for the property is related to the capital cost only if it can bear it and even then never exceeds 2½%.

When the property reaches the thirty-seven cow or six hundred ewe stage, its cost of development and market valuation are assessed. The lesser of these two is its option price to the settler. Normally these two valuations would be about equal but costs and conditions have changed and whereas the market valuation of the earlier schemes was 2½ to 3 times the cost of development, this ratio has been reversed for later schemes. The property is leased to the settler for perpetuity or he can exercise his right of purchase after six years.

Mr. Paul described briefly the procedure followed in the development of the major schemes. On King Island, Flinders Island and Waterhouse the schemes have been developed from virgin bush. Pastures are sown with a mixture of three pounds of perennial rye grass, three pounds of subterranean clover, and one and a half pounds of white clover. Two and a half hundredweights of copper-cobalt super is applied at seeding and lime is used in most parts. Annual topdressings are generally with one hundredweight of plain superphosphate.

On King Island 112 of the expected 164 farms have been developed and on Flinders Island 5,500 acres are to be developed providing 130-140 farms. Twenty per cent. of these are completed. Twenty farms, with a total acreage of 12,000 are expected to be completed at Waterhouse, in the North-East by next Autumn.

A very different pattern of development has been followed at Montagu swamp where a twelve mile long river-bed and subsidiary channels at the rate of sixteen to seventeen miles per year have been constructed. Some pasture has been sown down with eight pounds perennial rye grass, two pounds of paspalum, one and a half pounds of white clover and half a pound of strawberry clover. Alsike clover has also been sown successfully. There has been no indication that cobalt is needed but copper, and in some parts lime, are. It is hoped to obtain a hundred farms of one hundred and thirty acres in this area.

Despite difficulties in obtaining suitable land, labour and machinery 56% of the six hundred and eighteen registered applicants have been allotted farms and sixty one ex-servicemen from other states have been settled on King and Flinders Islands.

"Some problems in the breeding of sub-tropical pasture plants"

Dr. E. M. Hutton, Principal Research Officer, Plant and Soils Laboratory, C.S.I.R.O., Brisbane

The main problem is to determine what species are worth concentrated effort and which characters in the selected species need improving. Characters required in a grass or legume are:—high intake and utilization by the animal, often referred to as palatability; a long growing season and high dry matter production probably dependent on a short-day flowering response; maintenance of a high crude protein content with age; ability to recover rapidly from grazing; perenniality and persistence under grazing; resistance to drought and frost; resistance to insects and diseases; freedom from toxic principles.

A study of the breeding system of a number of legumes has been made. Bagging of racemes to find the degree of compatibility was successful as a considerable amount of bud-abscission occurred. It was necessary to study the pollination process in flower buds collected and "fixed" at different stages of development. *Indigofera endecaphylla, Phaseolus lathyroides,* and *Stylosanthes gracilis* are autogamous. With *Desmodium uncinatum* pollination occurs at tripping which always follows opening of the flower. All these legumes are self-compatible and variation is at a minimum in *I. endecaphylla, P. lathyroides* and *S. gracilis.* In *D. uncinatum* variations in flower and stem colour reflect the mode of pollination.

With *Leucaena glauca* some 170 small flowers are arranged in a "wattle-like" head, and these open about 3 a.m., the anthers being held over the stigma until anthesis occurs about 8 a.m. Due to this mechanism and a restricted period of anthesis, this species is mainly self-pollinated and populations of the different strains exhibit limited variability. The best strains come from Peru and El Salvador and crosses are being made between these to develop a vigorous type which retains its high protein leafage in winter. This perennial browse legume could

become important in areas where deferred grazing is practised.

White Clover, Centrosema pubescens, and *I. endecaphylla* are representative of the small group of pasture legumes which will withstand intensive grazing. *I. endecaphylla* is a promising coastal legume but contains primary aliphatic nitro compounds (one of which is β-nitro propionic acid) that cause a chronic condition terminating in the death of the grazing animal Some 2,000 single plants of all available strains of *I. endecaphylla* have been examined and the range in primary aliphatic nitro compound content was from 7.5 mgrms. to 18.0 mgrms. per gramme fresh weight. Intra-strain variation is limited, so attempts are being made to increase it by high energy treatments and interspecific crossing.

Grasses receiving attention are included in the genera *Sorghum, Paspalum, Setaria, Digitaria* and *Chloris.* In *Sorghum almum* an attempt is being made to develop a strain free from cyanogenetic glucosides. *Paspalum* and genera like *Panicum, Cenchrus* and *Brachiaria* contain a high proportion of apomictic species in which intra-strain variation is at a minimum. One approach in *Paspalum* is to find species with a degree of sexuality so that crosses can be made with them as the female parent.

"Male sterility in maize and its use in commercial hybrid maize seed production"

Mr. P. W. Grogan, Senior Lecturer in Plant Industry, Queensland Agricultural High School and College, Lawes

Male sterility has long been a recognised mutant in the maize plant. Early maize geneticists located many such genes in their various linkage groups and by 1935 twenty such independent recessives were listed by Emmerson, Boadle and Fraser. Each of these recessives is capable of bringing about complete or a high degree of sterility in the male inflorescence.

Rhodes in 1933 found a type of male sterility transmitted through the ovule only, i.e. its transmission was independent of the chromosomes, which he termed cytoplasmic male sterility. Gableman in 1949 further investigated this form of sterility and concluded that a discrete particle located in the cytoplasm was responsible. Such particles were transmitted through the ovule and the presence of a single particle was sufficient to suppress pollen formation. In 1952 Jones applied the terms "chromogenes" to the recessive mutants carried in the chromosomes and "plasmagenes" to the discrete particles located in the cytoplasm.

The possible use of this sterility in commercial hybrid maize production was investigated in the late 1940's by several plant breeders, Jones, Schwarz, Rodger *et al.,* each working with a different source of sterile cytoplasm. As the genetic picture unfolded possibility became fact so that in 1952 Rodgers produced some 2,000 bushels of Texas 18, a popular Texas hybrid, based on the male sterile factor. Today in the U.S.A. some 50,000 acres of crossing plots are producing commercial hybrid maize seed using cytoplasmic male sterilist to avoid detasselling.

In Queensland commercial maize hybrids are double crosses formed on four inbred lines. Hybrid seed production is carried out in two stages. The first cross is carried out at the Lawes breeding station for all hybrids. The single cross parent of the various hybrids are now released to approved farmers who carry out the final cross. The double cross seed is now available for bulk sowing.

In both the inbred and single cross stage of production one parent is selected as the ear or female parent, the other being designated the tassel or male parent. As the female parent in each case is the critical one in seed multiplication, the rate of sowing in the inbred crossing plots is 2 females to 1 male, and in the single cross crossing plots, 3 females to 1 male. To ensure purity of seed, both stages are carried out on areas isolated from other sources of maize pollen (20 chains minimum distance or 4 weeks planting time difference) and *all tassels must be removed from the female row plants before pollen is shed.* As the average number of female plants in an acre of single crosses ranges from 10,000 to 12,000 the time, labour and cost, not to mention the inconvenience of this detasselling programme is very considerable. The incorporation of the male sterile factor into these female plants does away with the need to detassel. Of the 10 commercial Lawes hybrids at present available, only one—Q23—was readily adaptable to production using male sterility to avoid detasselling. Yield tests to date indicate at least equal yields in both the single cross and double cross made on cytoplasmic sterility and the normal ones. U.S.A. figures indicate a higher single cross yield, due possibly to no loss of leaves which almost invariably occurs in detasselling. It is expected to adapt all commercial production of Q23 to the male sterile technique by the 1957-58 season. The programme of conversion is in hand at Lawes and it is estimated that within four years 75% of commercial hybrid maize will be produced on the cytoplasmic male sterile factor.

"Some notes on an overseas trip to the United States, the United Kingdom and the Continent with special reference to extension work"

Dr. W. A. T. Summerville, Director, Division of Plant Industry, Department of Agriculture and Stock, Queensland.

The speaker dealt briefly with the four International Conferences which he attended whilst overseas—namely, the International Conference on Arid Zones, the Commonwealth Agricultural Bureaux Conference, the F.A.O. School of Extension at Wageningen University and the International Horticultural Congress at Scheveningen, Holland.

Apart from these Conferences, most of the time overseas was devoted to the study of the flow of information from research workers and thence to farmers. In this connection, the conclusion reached was that the United States system of extension was more suited to Queensland conditions than any other studied, and that with modifications, it could be adapted to meet our requirements. The two key men facilitating

the flow of information were the Deans of the various colleges of agriculture associated with the Universities and the Subject Matter Specialists attached to the United States Department of Agriculture and the various State colleges.

The pre-service and in-service training were dealt with and it was pointed out that comparisons are not as clear cut as might be expected since the University degrees and agricultural college diplomas in various parts are not strictly comparable.

With reference to research work, the greatest amount of attention was paid to the agrostological side, and everywhere the essential feature of the work was aimed at the extension of the grazing season because of the high cost of winter fodder. Whilst there were many approaches to this subject there were three lines of attack which were common to virtually all institutions. These were grazing management, modification of climatic effects and the modification of environment, particularly soil conditions.

Insofar as management is concerned, some account was given of such procedures as duration of grazing, duration of spelling, deferment of grazing and questions bound up with species and strain selection of grasses and legumes. Questions of palatability and rationing of grasses through such practices as strip grazing, particularly by the use of the electric fence, were also dealt with. The evaluation of nutritional factors and the grazing habits of animals were touched upon. The use of such materials as chromic oxide for measuring intake, radio isotopes for studying nutrition and such physiological questions as root penetration were also dealt with.

BOOK REVIEWS

ALGAL CULTURE FROM LABORATORY TO PILOT PLANT

EDITED BY JOHN S. BURLEW

(*Carnegie Institute of Washington Publication No.* 600, *Washington D.C.*, 1953, *no Price.*)

The mass culture of algae is an attempt to produce useful organic compounds from the simplest ingredients, with an efficiency substantially greater than that achieved by the usual agricultural practices. Since plants are used as the synthesising units, the method is intermediate between agriculture and that complete factory synthesis of foods which, though seriously contemplated by some, is still rather far from practical achievement.

This book presents a reasonably full account of the work done up to 1953 under the auspices of the Carnegie Institute of Washington. It also includes accounts of work done on parallel lines in other parts of the world. There are five main sections. The first, of two chapters, sets out a summary of the project and states the case for its existence. Part two (six chapters) deals with the fundamental problems which are relevant to mass culture. The third section consists of eight chapters and deals with experiments on practical algal culture in various laboratories. It is interesting to note and compare the many different approaches to the common problems. Section four is of two chapters only. The first is an account of a pilot plant experiment at Cambridge, Mass., and the second is of a pre-pilot plant trial at the Tokugawa Institute at Tokyo. The fifth section is devoted to the possible uses of algal products, and is that which is likely to be the most significant to those interested in the project from an industrial point of view.

The book is well illustrated with photographs and line diagrams, and is provided with a bibliography of nearly 300 entries and with an index. The work described and the accounts given are, with one exception, of a uniformly high standard. While the inclusion of the work on multialgal cultures under natural and semi-natural conditions in Venezuela is justified for the sake of obtaining a complete account, it seems a pity that crude experiments described somewhat uncritically should appear in such a publication.

The impression left after reading this book is that one may be justifiably optimistic that, in the future of algal culture, there is a means of improving the living standards of those people of the world who stand most in that need.

E. G. BRITTAIN.

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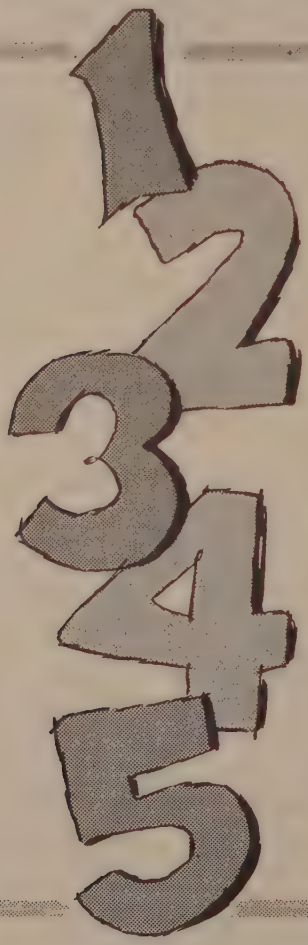

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PERSONAL NOTES

Australian Capital Territory

Mr. A. Shavitsky left in April to take up the position of Chief Scientific Liaison Officer at A.S.L.O. London. Prior to departure he visited most Divisions in C.S.I.R.O. to obtain a broad picture of the field of activities covered.

Mr. A. H. Gibson left for Rothamstead during June. He will work under Dr. P. S. Nutman.

Mr. C. I. Davern left during July to study at the Earhart Plant Research Laboratory under Prof. Went.

New South Wales

Mr. B. D. H. Latter has resigned from the position of biometrician with the N.S.W. Department of Agriculture. He has been awarded a Walter & Eliza Hall Travelling Scholarship from the University of Sydney and has left for overseas to spend a period of approximately two years to study at the Institute of Animal Genetics, Edinburgh.

Mr. J. McGarrity, lecturer in soils at the Sydney School of Agriculture has been awarded a Pawlett Scholarship from that University and will shortly leave to spend two years in postgraduate work at Oregon State College studying soil nitrogen problems.

Mr. A. H. Gibson who was on the staff of the C.S.I.R.O., Division of Plant Industry, was awarded a Gellibrand Scholarship and is studying soil microbiology at Rothamstead Experiment Station.

Official delegates from the N.S.W. Department of Agriculture to the 7th International Grasslands Congress to be held at Palmerston North, New Zealand from 6th-15th November will be Messrs. C. K. Vears, E. Cuthbertson, J. Strang and M. Walker. Messrs. F. G. Swain and L. Williams will be attending the Conference independently

Mr. A. C. Orman, Principal Agronomist (Vegetables) in the N.S.W. Department of Agriculture, visited the Northern Territory during July at the invitation of the Commonwealth Department of Territories to investigate and report on vegetable production there with the object of increasing local production to meet local needs.

Queensland

Mr. A. A. Ross, Horticulturist, Department of Agriculture and Stock, has been seconded to the Standards Branch, and *Mr. W. V. Mungomery* has been transferred from the Redlands Experiment Station, Ormiston, to Maryborough, in order to take up the horticultural duties relinquished by Mr. Ross.

Mr. W. J. Bissett, formerly of C.S.I.R.O., has been appointed to the Department of Agriculture and Stock as pasture improvement officer at Emerald. *Mr. T. E. Graham*, Agrostologist, is also to work in the Central Highlands, being stationed at Rockhampton.

Mr. R. W. Downes, Plant Breeder, Department of Agriculture and Stock, has been transferred to the Irrigation Research Station, Gatton, to undertake genetic and cytological investigations with Queensland blue grass (*Dichanthium sericeum*).

Mr. A. F. Bell, Under Secretary, Department of Agriculture and Stock, delivered the John Thompson lecture for 1955 on 14th June, 1956, by invitation of the Professorial Board, University of Queensland. The lecture, which dealt with the "Story of the Sugar Industry in Queensland" and arranged to be delivered on 6th September, 1955, was postponed on account of Mr. Bell's absence from Queensland. At that time, he attended talks held in London reviewing the Commonwealth Sugar Agreement (1951) and an F.A.O. conference in Rome.

A trip to the Grassland Conference in New Zealand towards the end of the year is in store for Hon. Secretary, *Mr. Stan Waring*. This trip has been sponsored by the Commonwealth Government Extension Grant.

Dr. E. F. Henzell, Queensland Rhodes Scholar for 1951, returned to Queensland during late December, 1955, after more than three years at Oxford University (1952-55). He received his Ph.D. at Oxford as a result of studies relating to the "Physiology and Action of 2.-4-D." On the completion of his studies he spent three months touring Europe and visiting scientific institutions in Germany, Sweden, Holland and Italy. Dr. Henzell was married last June at Oxford and honeymooned in Cornwall. He has been appointed to the staff of the Plant and Soils Laboratory, C.S.I.R.O., as Research Officer to investigate the nitrogen cycle in soils and plants under sub-tropical conditions.

Congratulations to *Dr. S. T. Blake* of the Government Botanist's Section of the Department of Agriculture and Stock. Dr. Blake has recently been awarded his D.Sc. for systematic and ecological botany.

Congratulations also to our Branch President, *Professor L. J. H. Teakle*, on his election as the first Federal President of the Australian Society of Soil Science.

Mr. E. B. Rice, Director of Dairying, Department of Agriculture and Stock, has left for a four months visit to Europe and America to study latest overseas trends in dairying, including modern milk marketing. He will go to the United States, the United Kingdom, Sweden, Denmark and Holland before attending the International Dairy Congress at Rome in September. He returns to Brisbane in November.

Dr. E. Phillis of the Land Research and Regional Survey Division of the C.S.I.R.O. passed through Brisbane recently and conferred with members of the Department of Agriculture and

Stock, the University and C.S.I.R.O. Dr. Phillis has been studying the water relations of crops at Katherine.

Mr. Owen Sturgess recently resigned from the Plant Pathology Section, Department of Agriculture and Stock to commence duties with the Bureau of Sugar Experiment Stations.

Mr. Brian Egan, Plant Pathologist of the Brisbane office of the Bureau of Sugar Experiment Stations, will leave Brisbane on August 1st on transfer to Meringa Experiment Station.

Mr. Don Tulloch, formerly Agronomist, Department of Agriculture and Stock, has recently joined the staff of Henry H. York and Co. as Technical Officer, Agricultural Section.

Mr. Col. Brett recently resigned from the Department of Agriculture and Stock, Pittsworth, to join the staff of Kalamia Estates, Ayr.

Mr. Tom Denmead of C.S.I.R.O. is at present carrying out national service training in the R.A.A.F.

Victoria.

Mr. J. J. Lenaghan of the C.S.I.R.O. Agricultural Research Liaison Section left for the U.S.A. in August. He will take up an assistantship in the Department of Agricultural Journalism at the University of Wisconsin for the academic year 1956-7. Mr. Leneghan has given valuable service as Hon. Recorder for the Victorian Branch for the past 3 years. *Mr. B. Sellars* of Grazcos has agreed to fill this office.

Mr. N. W. Moore has obtained his M.Agr.Sc. with work over the past two years on hormone inter-relations in the oestrus cycle of the ewe, and large scale synchronisation of oestrus for artificial breeding.

He left for Cambridge in August on a C.S.I.R.O. Scholarship and a Giblin Studentship to King's College. He will continue studies in the field of reproductive physiology for 2 years.

Mrs. Moore who was formerly *Noel Thomas, B.Agr.Sc.,* is travelling with him. She has been a microbiologist with Kraft Foods for the past 2½ years.

Dr. H. C. Forster, Assistant Executive Officer of C.S.I.R.O. is scheduled to return in October from a six month visit overseas. He is visiting Agricultural Research Establishments and Universities in Britain, Europe, Canada and the U.S.A. He also visited F.A.O. headquarters in Rome on his forward journey.

Mr. Geoffrey Loftus Hills, O.I.C., Dairy Research Section, C.S.I.R.O., is on a four months visit overseas. He is visiting Dairy Research Centres in England and Europe and will attend the 14th International Dairy Congress in Rome this month.

Mr. E. Campion, B.Sci. (Agric.) has forsaken his native State in favour of Victoria. He has taken up the position of Field Officer (Livestock) at the Melbourne and Metropolitan Board of Works Farm at Werribee.

BRANCH NOTES

Australian Capital Territory

On 12th July the branch held a symposium entitled "Recruitment of Agricultural Scientists." Speakers were Mr. W. M. Willoughby, Dr. E. Phillis, Mr. R. Milton Moore and Mr. F. Grogan.

A report of the symposium will be published in the December issue of this Journal.

New South Wales.

The ordinary meeting of the Branch on 13th April took the form of a symposium, the subject for discussion being "Economic barriers to agricultural progress." The guest speakers were Mr. J. N. Lewis, Assistant Director, Bureau of Agricultural Economics, Canberra, Mr. A. J. McIntyre, Rural Information Section, Commonwealth Bank, Sydney, and Mr. Ross Parish, Agricultural Economics Section, N.S.W. Department of Agriculture.

Mr. Lewis discussed external constraints on agricultural development in Australia, the spread of national policies of self sufficiency in agriculture and the effects on our trade of surplus disposal activities and of export subsidies by other countries.

Mr. McIntyre was concerned mainly with rural credit facilities. Mr. Parish felt that inadequate extension services were a real barrier to progress and made a plea for more applied research as perhaps the principal means whereby the quality of extension services can be raised.

At the Branch meeting on 29th June which was held jointly with the N.S.W. Branch of the Animal Production Society, Mr. J. L. Shute, Chairman, Australian Meat Board, spoke on "The future of our export meat trade" and Dr. R. T. Clarke, Co-ordinator of Beef Cattle Research, U.S. Department of Agriculture, spoke on "Beef Cattle research and its application to industry."

By arrangement with the Dean of the Faculty the Branch participated in the activities of the School of Agriculture on the Sydney University Open Day on 21st July. The careers advising section was staffed by members of the Institute and by means of slides, talks and distribution of literature the attractions of a career in agricultural science were made known to the large numbers of visiting public.

Recruitment to the profession of agricultural science was also furthered by the participation of the Branch in the Careers Exhibition held in Sydney from 27th-31st August. The staging of an attractive exhibit was financed by a grant from Commonwealth sources.

At a recent meeting of the management committee some doubts were expressed of the soundness of the assumption behind the Institute's recruiting campaign that there will be an increas-

ing demand for the services of agricultural graduates. It was felt that this aspect of future agricultural development in Australia should be carefully discussed at the federal level in the near future.

Queensland

The main business conducted at the 130th Ordinary General Meeting of the Branch, and held on the evening of 30th May, 1956, was an interesting and well developed address by *Dr. W. A. T. Summerville*, entitled "Some notes on an overseas trip to the United States, the United Kingdom and the Continent with special reference to extension work."

A special film evening was convened on the 13th June, 1956, to view four 16 mm. films forwarded to this Branch by courtesy of the office of the High Commissioner for South Africa.

At the 131st Ordinary General Meeting held on 27th June, 1956, *Dr. E. W. Hutton* and *Mr. P. W. Grogan* presented two informative addresses dealing with "Some problems in breeding of sub-tropical pasture species" and "Male sterility in maize and its utilisation in commercial hybrid maize seed production", respectively.

The Public Meeting for 1956 was held on Wednesday, 22nd August, in the Shell Theatrette, Ann Street, Brisbane, commencing at 8 p.m. The main business of the meeting was a discussion on "Conservation of Soil and Soil Fertility".

A farmer from Yandilla, *Mr. S. O. Cowlishaw*, was invited to present the practical aspects of the problem together with direct questions on the subject. Mr. Cowlishaw, who is President of the Queensland Grain Growers' Association, recently attended the conference of the International Wheat Agreement in Geneva, as an Australian delegate.

A second speaker, *Mr. W. J. Cartmill*, Chief Soil Conservationist, Department of Agriculture and Stock, replied to Mr. Cowlishaw's questions and also outlined the general principles involved in the conservation of soil and of its fertility.

The Branch will conduct its annual Field Day meeting on 22nd September, 1956, at the Queensland Agricultural High School and College, Lawes. Last year, this type of meeting which was an unqualified success, was convened at Maroochy Experiment Station, Nambour.

Tasmania

The following office-bearers have been elected for 1956.

President—Prof. H. N. Barber.
Vice-President—Mr. K. D. Nicolls.
Secretary—Mr. D. Berry.
Treasurer—Mr. K. W. N. Dillon.
Journal Sub-Editor—Mr. I. D. Geard.
Publicity Officer—Mr. L. R. Pyke.
Committee Members—Mr. E. J. Martyn and Dr. J. H. Wilson.

On 22nd June a meeting was addressed by Mr. R. A. Paul, Acting Director of War Service Land Settlement for Tasmania.

Victoria

On 21st August a meeting was addressed by Professor James Bonner, Professor of Biology at the Californian Institute of Technology.

Prof. Bonner spoke on "The Chemical Control of Plant Growth."

FEDERATION OF RHODESIA & NYASALAND

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Starting Salary (N.B.—£1 Rhodesian = £1 Sterling) £650-£1,100 p.a. depending on quals and exp. on scale rising to £1,600. (An entrant with a four-year or good honours degree would start at £800; with four years' relevant experience at £1,100 p.a.) Promotion beyond this point is possible.

Applications in writing, giving details of age, marital status, qualifications, experience, availability, together with the names and addresses of two referees, should be sent BY AIRMAIL to the Director of Research and Specialist Services, P.O. Box 8025, CAUSEWAY, Salisbury, Southern Rhodesia, within three weeks of the appearance of this advertisement.

BOOK LIST

Notice has been received that the following books on agricultural topics have been published recently:—

BENTLEY, Maxwell—Growing plants without soil. *Johannesburg, Hydro-chemical Industries,* 1955. £5/7/6.

BRITISH POULTRY STANDARDS — *London, Poultry World,* 1955. 25/- stg.

CALLAGHAN, A. C. and MILLINGTON, A. J.—Wheat industry in Australia. *Melbourne, Angus and Robertson,* 1956. 63/-.

DUNSDORFS, Edgars—The Australian wheatgrowing industry. *Melbourne, University Press,* 1956. 55/6.

ELECTRICITY SUPPLY ASSOCIATION OF AUSTRALIA—Farm electrification handbook. *Melbourne, Elect. Supply Assoc.,* 1956.

FEDERER, Walter T.—Experimental design: theory and application. *New York, Macmillan,* 1955. £3.

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS—Agriculture in the world economy. *Rome, F.A.O.,* 1955. $1.00 or 5/- stg.

FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS—So bold an aim. *Rome, F.A.O.,* 1955.

HAMBIDGE, Gove—The story of F.A.O. *New York, Van Nostrand,* 1955. $6.50.

ROY, J. H. B.—The calf; its management, feeding and health. *London, Farmer and Stockbreeder,* 1955, 5/- stg.

STATE ELECTRICITY COMMISSION OF VICTORIA—Manual of electric pumping. revised. Sept., 1955.

U.S.D.A.—Yearbook of agriculture, 1955: Water. *Washington, Govt. Printing Office.* 1955. $2.00.

WORMALD, H.—Diseases of fruits and hops. 3rd ed. rev. *London, Crosby Lockwood,* 1955. 25/- stg.

WRIGHT, R. C. M.—Plant propagation. *London, Ward Lock & Co.,* 1955. 25/- stg.

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